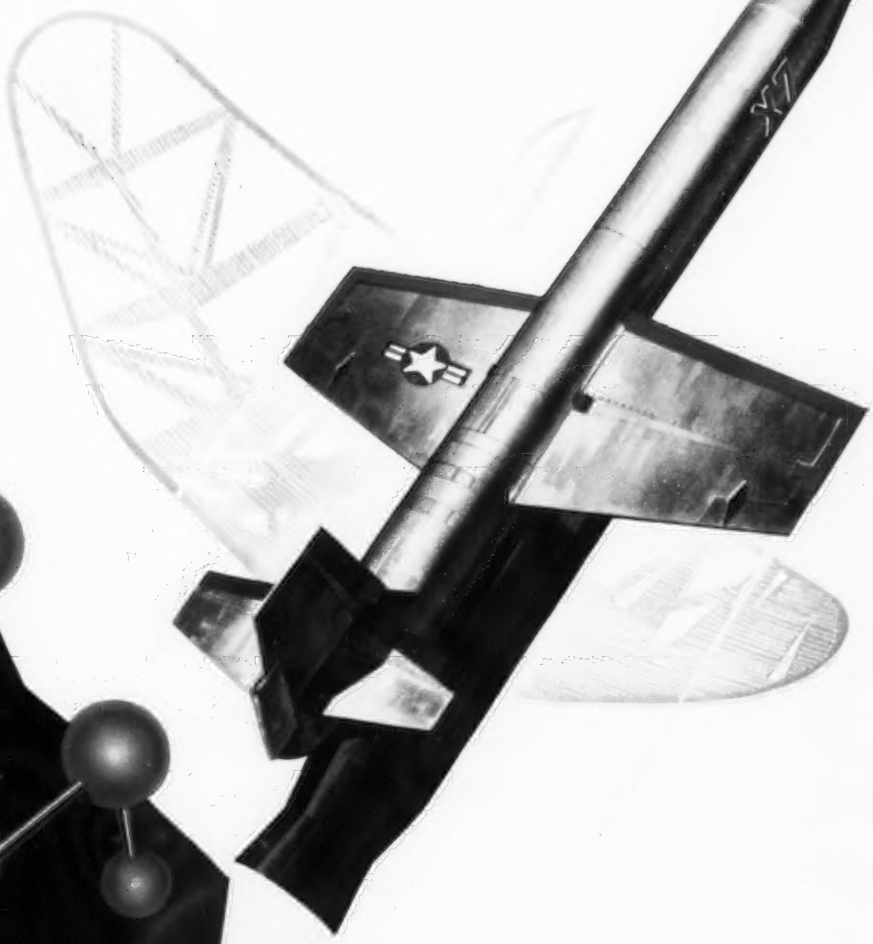
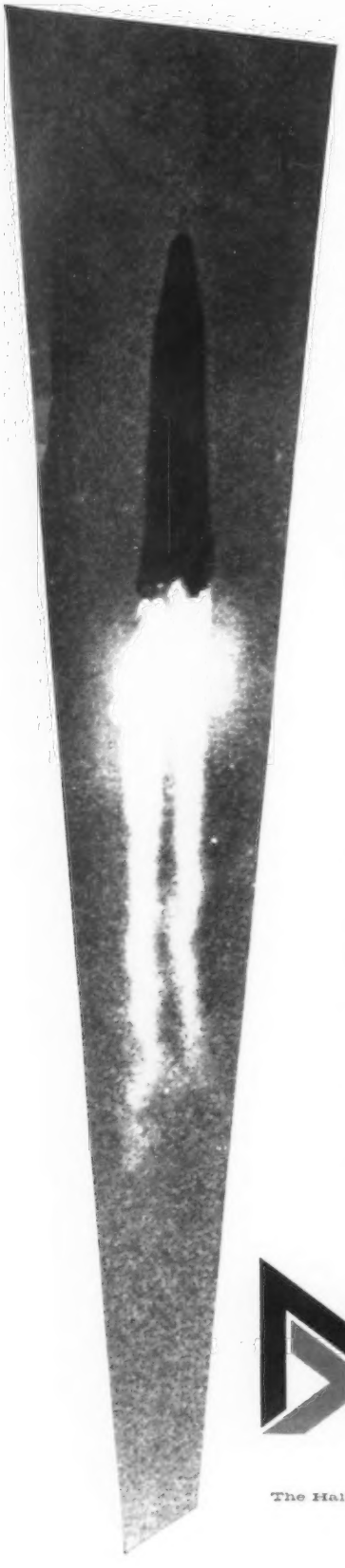
# AIRCRAFT AND MISSILES MANUFACTURING

A CHILTON PUBLICATION

JUNE 1958

DESIGN • PRODUCTION • PROCUREMENT





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In today's missiles and aircraft, so much depends upon so little! As aircraft and missile men know, failure of just *one* of the many components linked together in complex systems, can put the whole system "out of business." *Every part* has become a critical part!

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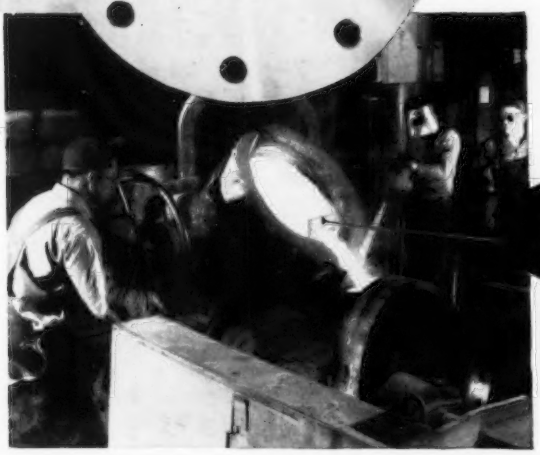

Tremendous pressures and temperatures are generated in this shock tube at Lockheed Aircraft Corp., to simulate conditions encountered by a long-range ballistic missile re-entering the earth's atmosphere. High pressure gas triggers shock waves which travel 17 times the speed of sound. Instantaneous temperatures range above 15,000 degrees F.

The 44-foot long tube is an assembly of *ESCO* heavy-wall Spuncast® castings hydrostatically tested at 10,000 PSI. It is typical of the many exacting casting jobs that wind up at *ESCO*.

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Circle 31 on Inquiry Card, page 65

# contents

JUNE 1958

VOLUME 1, NUMBER 6

DESIGN
PRODUCTION
PROCUREMENT

A CHILTON PUBLICATION

## THE COVER STORY

Chemistry and electronics are being relied upon heavily to provide man with his wherewithal for the conquest of space. In an effort to cope with the increasing need for new materials, the building blocks of nature are literally being rearranged into new patterns, while electronics is being utilized to extend the invisible spaceways into the future.

## FEATURES

PAGE

7 Vanguard details revealed

20 Teflon—high and low temperature properties

25 turbine blades produced automatically

28 fluoroelastomer

32 reliability . . . keynote of Redstone engine

37 braided casting-cores

40 Lox tanks for Thor

42 trends in high-temperature metals

48 "hard anodizing" magnesium

## DEPARTMENTS

PAGE

4 editorial orbit
53 zero infinity
54 producibility review
57 materials and components
63 new for production
72 men on the move
74 worth asking for
84 your date book

## INDUSTRY NOTES

76 french-designed Statoplan for private flying
76 maiden flight for F-27
77 lycoming to produce helicopter gas turbine
77 electra chosen for anti-sub warfare
78 commercial jet engines
78 air-to-surface bullpup found accurate
79 large inductance coil used for missile study
79 two icbm sites announced for sac
79 machining rocket parts
79 aircraft temperature
80 industry statistics
81 stainless icbm
81 space challenge cited for ball bearings
81 trim vanguard set for I.G.Y. try
82 gun pod strengthens navy aircraft
82 machine tool builders in world market
83 terra-scope

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Circle 32 On Inquiry Card, page 65

## Time to Abate Missile Fever

Expenditures for manned aircraft are declining, while spending for unmanned aircraft is increasing. Right now, 21 cents out of each aircraft and missile dollar is used for missiles. Next year, it will be 26 cents. Back in 1952, only 1½ cents per dollar was allocated for the missile program.

Just for space exploration this year, the U. S. is spending $100 million. Next year, $300 million. By 1967, it is anticipated that we will hit the billion dollar mark.

Sometime in the future, conventional military aircraft expenditures will be below that of military missiles and spacecraft. Exactly when the two curves will cross is anyone's guess at the moment.

Does this mean that we are going to do away with conventional aircraft? Not at all.

Actually, the budget for manned airborne vehicles—for civilian and military use—will continue to take a huge share of the total outlay. The curve will level out; it will not go to zero or anything close to it.

Remember, we must still develop higher performance aircraft for a variety of missions—supply, long and short haul transport, strategic power, close support of ground troops, air-sea operations, evacuation in peace and war, and other phases of air travel not feasible with missiles or space vehicles.

Much work must be done in shortening landing and take-off distances for jets, gas turbine fuel economy, jet silencing, mid-air collision detectors, and a host of other items that will provide an even higher degree of safety and efficiency than that which we enjoy today.

We definitely do not foresee any abrupt end to the usefulness of the human pilot as long as there is an Earth to live on.

This is one of the reasons why AMM provides an equal coverage of both aircraft and missile programs. Neither should be exploited at the expense of the other.

Technological advances in each go hand in hand.

Editor

# Narda SonBlasters offer the most complete line of lowest-cost mass-produced ultrasonic cleaners!

Narda's mass-production techniques assure you the most complete line of ultrasonic cleaners at the lowest prices in the industry! From the smallest 35-watt to the amazing 2500-watt unit with a tank capacity of 75 gallons, Narda's SonBlasters are available **now**—off-the-shelf—for immediate delivery. And with a full 2-year warranty besides!

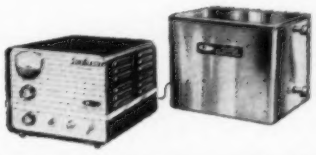
What do **you** want to clean? Hot lab apparatus, medical instruments, electronic components, automotive, missile and avionic components, optical and technical glassware, timing mechanisms—Narda's SonBlasters clean 'most any mechanical, electrical or horological part or assembly you can think of—and clean faster, better and cheaper.

No matter what you need in ultrasonic cleaning equipment, you'll find Narda's complete line of production-size units have the quality, power, performance, capacity and appearance of cleaners selling up to three times their price! Write for more details **now** and we'll include a free questionnaire to help determine the precise model you need. Address: Dept. AMM-16.

**Generator G-202** **Transducerized Tank NT-202**
**35 watts** **Capacity: ⅜ gallon**

An amazingly efficient, yet inexpensive, ultrasonic cleaner. Duty cycle timer permits operator to turn the unit on, set it, and leave; the SonBlaster will turn off automatically at the end of the cycle. Four choices of timers—from 0-15 min. to 0-120 min. Also available without timer at slightly lower cost (G-201).

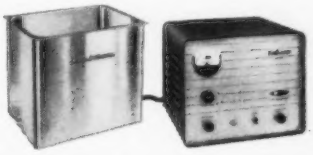
**$220**



**Generator G-601** **Transducerized Tank NT-602**
**60 watts** **Capacity: 1 gallon**

A more powerful production-type unit, with a special circuit and selector switch permitting operator to alternate between two tanks, when items being cleaned require different solutions or a two-step process.

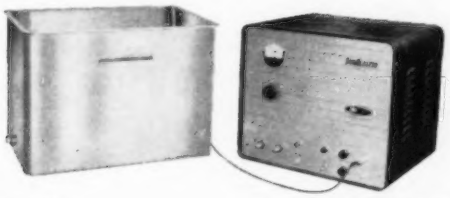
**$350**



**Generator G-1501** **Transducerized Tank NT-1505**
**200 watts** **Capacity: 5 gallons**

The lowest price in the industry for a tank of this capacity and activity. Generator also will operate 2, 3 or 4 submersible transducers at one time, with just a turn of the load selector switch on the front panel.

**$695**



**Generator G-5001** **Transducerized Tank NT-5001**
**500 watts** **Capacity: 10 gallons**

Generator features standby switch for longer life and load selector switch on the front panel to operate up to 8 submersible transducers or 8 NT-602 or 2 NT-1505 transducerized tanks at one time. Larger tanks available on special order.

**$1325**

**Submersible Transducer NT-605**

Heli arc welded stainless case, hermetically sealed for safe, leak-proof immersion. Radiating face: 27 sq. in. Effective plane of radiation: 40-50 sq. in. (approximately 10" x 5"). Effective cavitation of volumes up to 1200 cu. in. at 24 in. tank height (5 gal.) and 2400 cu. in. at 48 in. tank height (10 gal.). Bulkhead electrical fitting on back allows all wiring connections to be made on outside of tank. For use in any arrangement or location in any shape tank you desire to use. Also available—model NT-604, identical with NT-605, except for pipe thread instead of bulkhead fitting, permitting electrical connections inside of tank.

**$130**

Consult with Narda for all your ultrasonic requirements. The SonBlaster catalog line of ultrasonic cleaning equipment ranges from 35 watts to 2.5 KW, and includes transducerized tanks as well as immersible transducers which can be adapted to any size or shape tank you may now be using. If ultrasonics can be applied to help improve your process, Narda will recommend the finest, most dependable equipment available—and at the lowest price in the industry!

**Generator G-25001**
**2500 watts**

The largest mass-produced industrial-size transducerized ultrasonic cleaning tank made! (Tank NT-25001; capacity: 75 gallons.) G-25001 generator also energizes up to 40 submersible transducers.

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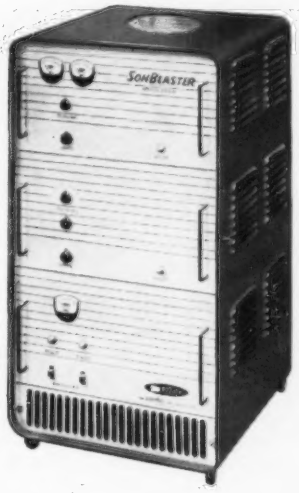


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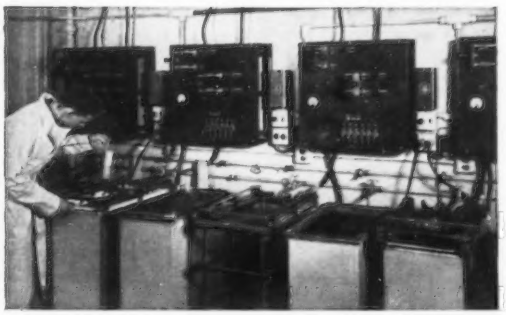

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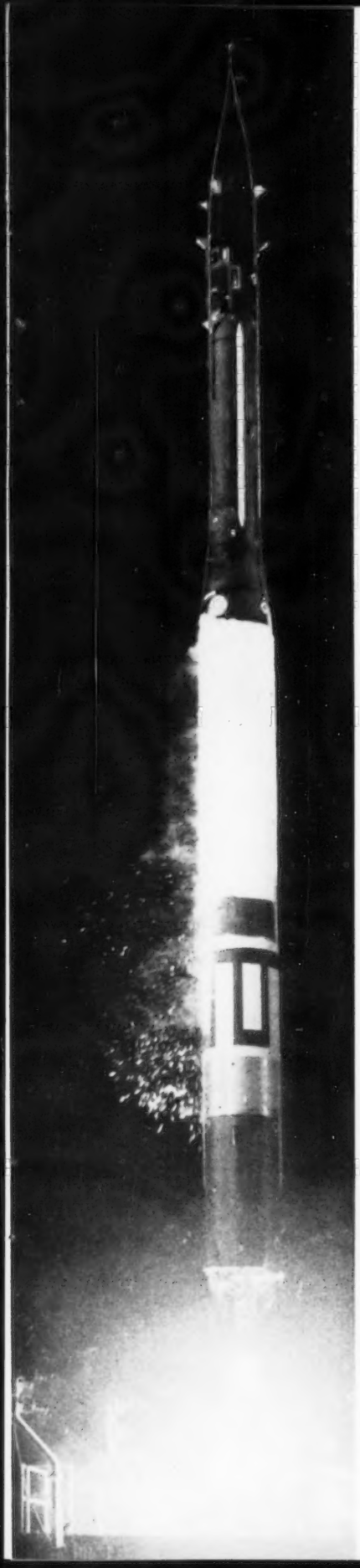

Vanguard vehicle leaves launching pad in TV-5 test. Third-stage failed to ignite.

Latest Vanguard effort was SLVI (Satellite Launching Vehicle I) on May 27. Objective was to place a 2½ lb instrumented sphere in orbit. All stages ignited, but no orbit was achieved.

# Vanguard details revealed

## design, materials, and methods of construction for a temperamental missile

by John P. Kushnerick

The slim 72 ft, three-stage missile called Vanguard has been as tempermental as the little girl with the curl. When it has been good, it has been very, very good, but when it has been bad, it has been horrid.

Count-downs have been prolonged, delayed, and postponed for almost every conceivable reason. Missile launchings have ranged from disastrous to stupendous; and satellite launchings have gotten variously from 72 ft off the ground to a colossal accidental height in an orbit that is yet to be matched.

The successful orbit achieved on March 17 was, by a Vanguard official's own admission, a well planned accident. The "grapefruit" satellite was installed in TV-4 only on the outside chance that untested hardware in the second and third stages would function correctly. The gamble paid off for this has been the face saving achievement of almost the entire project. The first real attempt to place a fully instrumented satellite in orbit on April 17 was unsuccessful because of the failure of the third stage rocket to provide orbital velocity.

Vanguard has been described in some quarters as the first of a new breed, a completely refined missile with a propulsion system built from scratch. This is given as reason for the several "failures." This borders on alibi talk. "Vanguard is neither a completely new system nor is it made up of 'off the shelf' hardware. Its technical roots dig into the fertile ground of previously established propulsion techniques, while several new approaches have been added which go beyond established techniques." (Kurt R. Stehling, NRL).

*continued on next page*

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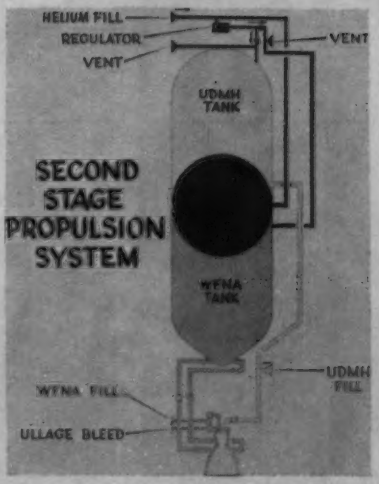


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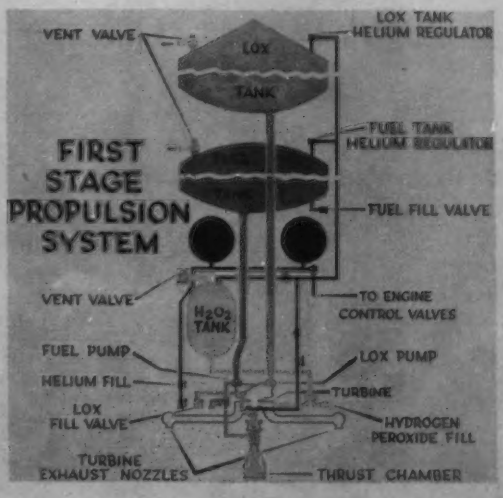

# Vanguard details revealed

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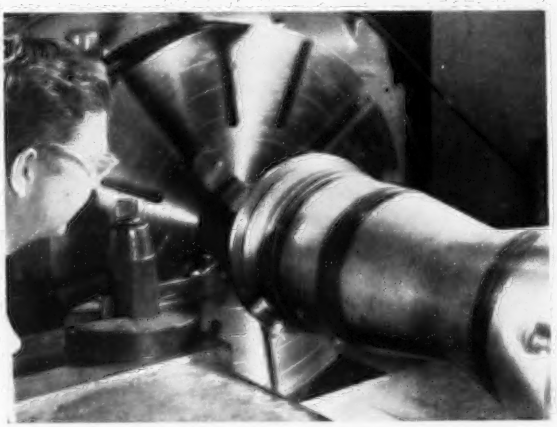

First-stage, rocket-motor, base plate is machined after outer jacket is welded in place. Welds are evident as dark areas.

Helix for regeneratively cooled rocket motor is welded on the inner jacket of the motor. 4130 steel is major material of construction.

The several areas where refinements have been made place the three rocket motors on the fringes of ideal combustion efficiency with existing fuels. This has presented a problem in heat transfer and ability of existing materials to cope with combustion chamber temperatures.

### First Stage Rocket Engine

The 27,000 lb thrust first stage rocket is liquid propelled. Design is such that a coolant flowing between the inner and outer shells of the thrust chamber is able to absorb the heat flux necessary for maintaining the integrity of the combustion liner.

The rocket motor is constructed largely of 4130 steel. It consists of an inner jacket and an outer jacket. A precision wound helix is welded to the inner jacket to provide circulatory passage for the kerosene fuel which enters the cooling jacket at the base of the rocket. The kerosene simultaneously removes heat of combustion from the liner walls and absorbs heat to make its own combustion more efficient.

The inner shell is fabricated on a Hydroform machine. The venturi section of the outer shell is roll-formed in two sections then welded. The upper and lower sections of the 4130 outer case are also roll-formed in two sections then welded to the venturi on a master gage.

The first stage kerosene and liquid oxygen (LOX) fuels first come together at the top of the combustion chamber after making their way through separate passages in the 16 ring injector plate. About 1600 holes are precision drilled and then brazed in the 300 series stainless steel rings.

The rocket is gimbal mounted to provide 8½ deg movement from the vertical axis through a 360 deg arc. That is, the engine may be hydraulically deflected from the perpendicular, following an inverted cone shape to a maximum deflection of 8½ deg. This is to provide steering since the missile has no vanes.

### Master Gages

Thrust is transmitted through four legs of 6061 aluminum which connect the motor to the first stage of the missile. The fact that the thrust unit is fabricated at General Electric, Evandale, and the first stage and engine mounts are fabricated at The Martin Co., Baltimore, has made the use of master gages imperative. This tooling problem is not restricted to the first stage. The extensive subcontracting on Vanguard has been responsible for a planned master gaging program that is a major project in itself.

Because the third-stage rocket is solid propelled and is handled only at the firing site, master gages are supplied and used extensively by the subcontractor and Martin plants to ensure the proper fit and function of this most critical point of the launch vehicle. It is a "function" because it is this section that is used in the spin-stabilized launch of the satellite itself. The spin table, bearings and bottle sizes, and locations are all very critical, and this portion of the master gaging program has received very close attention.

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# Vanguard details revealed

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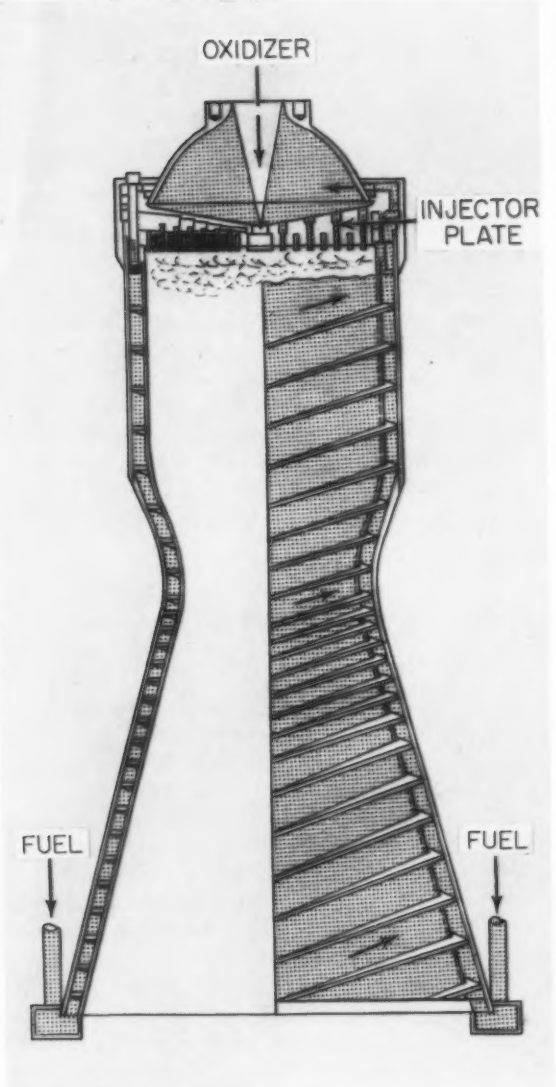
Injector is composed of 16 concentric rings which are brazed in place after the variously sized holes are drilled to provide passage for liquid propellants.




Cutaway of first stage rocket motor shows how helix provides passage for kerosene fuel to cool combustion liner. Kerosene and LOX enter combustion chamber at top through 1600 individual holes in the injector ring.

### First Stage Airframe

The relationship of load carrying capability to airframe weight dictated the use of new materials and new manufacturing techniques. Magnesium is used wherever possible to reduce structure weight. An interesting facet of this materials and fabrication problem lies in the technique of building integral fuel and oxidizer tanks for the first two stages. These tanks are constructed so that tank walls are also the missile's structural skin.

The tanks are built of an outer skin, internal frames, end frames, and domes.

### Materials and Methods of Construction

6061-T6 aluminum, (Reynolds) is the principal alloy in the 44 ft first stage. At the longitudinal splices of the skins a spot welded doubler is used to structurally join them together. Bent-up flanges on the skin are then fusion welded by hand. The spot welds are used to provide structural integrity, while the fusion welds principle is carried into the end frame where an aluminum extrusion provides a welding flange.

The internal frames and longerons are all made of 7075-T6 or 2024T3 aluminum.

All the spot welding is accomplished before any fusion welding is done. A three-part, collapsible header framing-tool of fiber glass tubing and aluminum is used in this operation to locate the frames and provide holding contours.

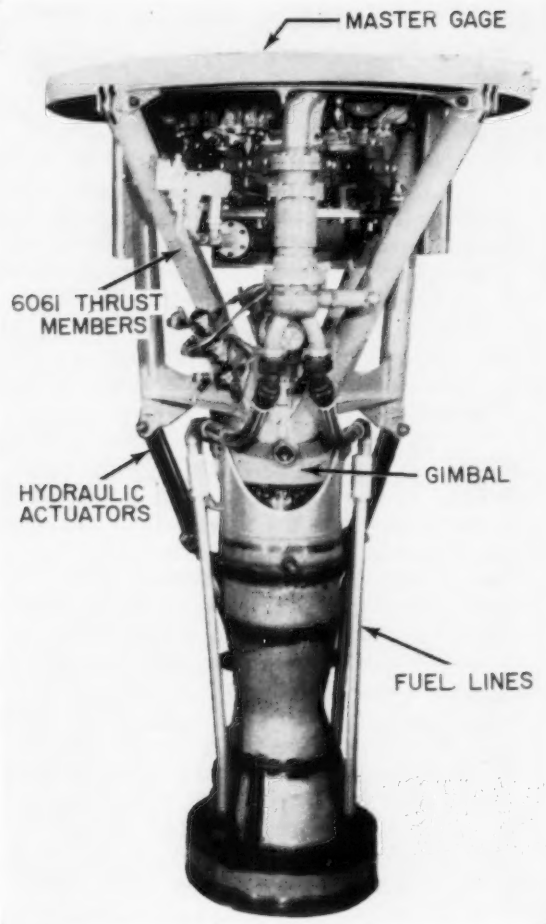
The domes of the tanks present a different problem because the tank is being closed. This makes spot welding impossible. Hence fusion welding is relied upon for both structural and sealing integrity. A scalloped edge dome was chosen to provide more inches of welding in a given distance. A scalloped doubler is spot welded to the dome to compensate for the heat-affected zone of fusion welding.

The spot welded tank and domes are placed in the alignment and tack welding fixture where accurate alignment of the rocket components is begun. This is a simple but accurate holding fixture.

After this operation, the tacked assembly is placed in a rotary fusion welding fixture where the longitudinal welds, the end frame lateral welds, and the dome scalloped edge are hand welded. The tank is then subjected to its first pressure test by using a very low air pressure and soap and water for bubble detection of leaks. Primary leaks are repaired by welding at this point.

The tanks are transported by specially designed trucks to an area where they are hydrostatically tested to prove the structure. As the tank is drained, and the test water is weighed to

*continued on page 12*

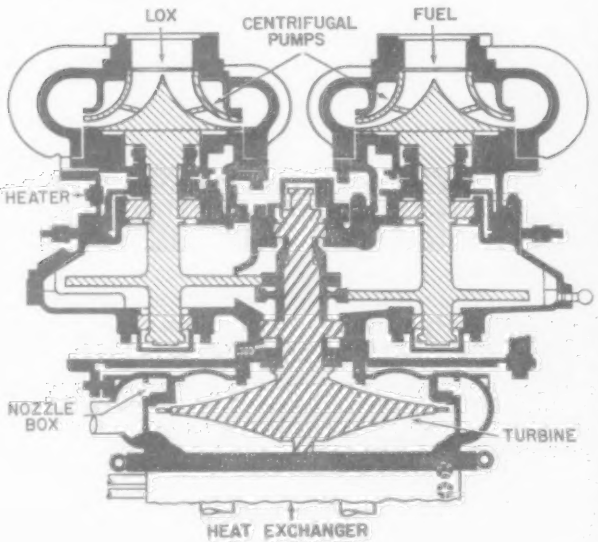


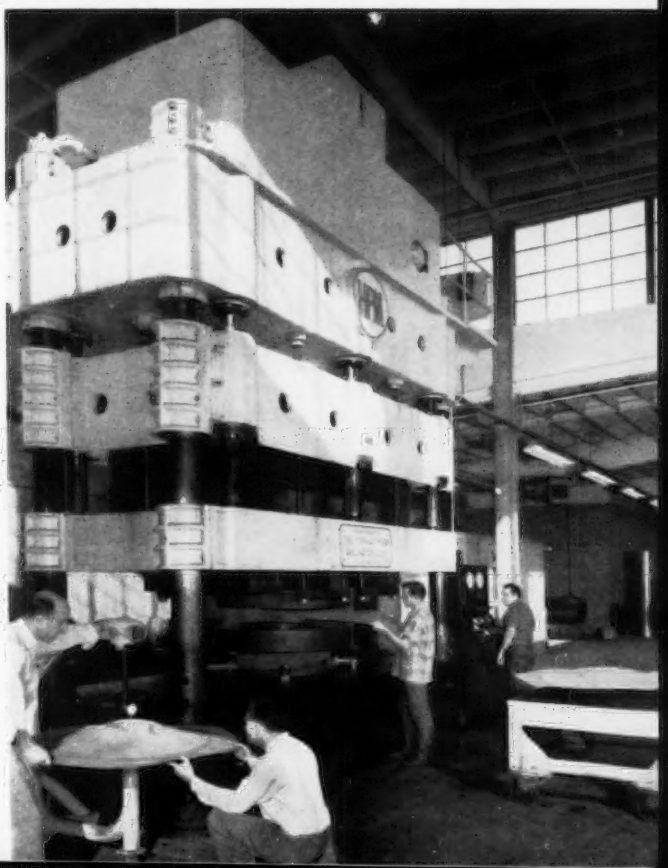

**Completed first stage rocket motor shows gimbal mounting.**

Kerosene tank of first stage is made of 6061-T6 aluminum sheet. Spot welds provide structural integrity, fusion welds give leak integrity. Scalloped edged dome was designed to give more inches of welded area.

**Propellant tank heads for second stage. Integral tanks are checked after drawing operation. Tankage is of 410 stainless.**

Cutaway of turbo pump assembly. Pump is powered by steam resulting from decomposition of hydrogen peroxide. LOX and kerosene pumps are driven by this turbine.



# Vanguard details revealed

**continued**

accurately calibrate the tank volume. It is then pressurized with helium to give it a gaseous test. Then, using filtered water, detergents, and special cleaning heads, the tank is surgically cleaned and chromastetized to put a final surface finish on both the inside and outside of the tank.

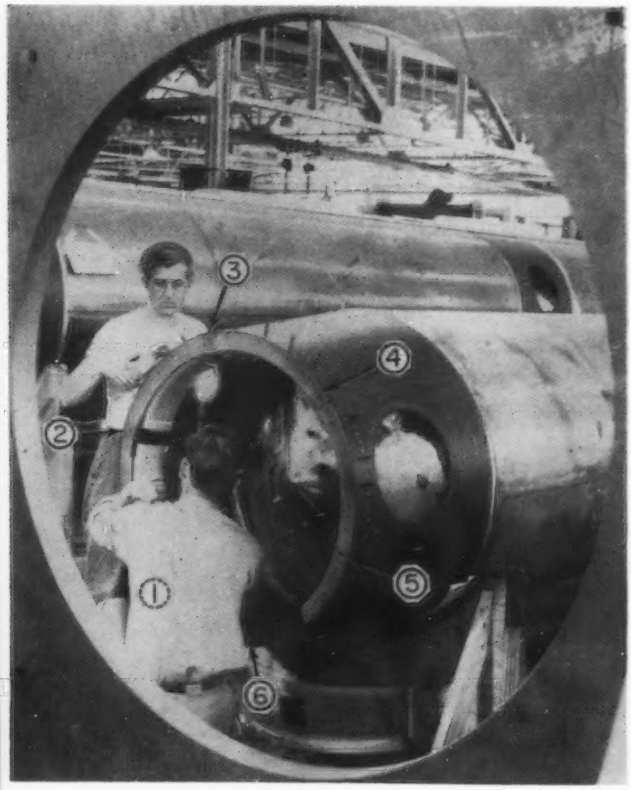
The fuel and liquid oxyen tanks are not the only ones thus tested. High pressure testing of helium tanks and medium pressure testing of hydrogen peroxide and propane tanks are also performed.

The small portions of the first stage airframe that do not constitute tankage, house electronic gear, pressuring tanks, turbo pumps, etc. These are constructed of magnesium alloy, selected for its lightness.

### Second Stage Engine

The transition section and aft skirt that tapers to the second stage are made of magnesium-thorium sheet. At an altitude of about 35 to 38 miles, six explosive bolts containing PETN are electrically detonated to release the spent first stage.

View through fixture which aligns first and second stages to 0.095 in., shows attachment points for six explosive bolts which separate first and second stages.




The second stage power plant is a liquid-propelled, regeneratively-cooled unit, which provides about 7700 lb of thrust for about 120 sec.

The propellants used are: inhibited white fuming nitric acid (IWFNA) as the oxidizer, and unsymmetrical dimethyldrazine (UDMH) as the reducing agent. The propellants are pressure-fed to the thrust chamber by pressurized helium. Injection into the combustion chamber is at a nominal mixture ratio 2.8 to 1.0. No ignition system is necessary since the propellant combination is hypergolic.

The second stage thrust chamber does not operate at the high chamber pressure typical of the first stage motor. Low chamber pressure reduces the heat rejection rate and may increase the gas film heat transfer coefficient. At the same time, the liquid film coefficient is reduced, and saturation temperature of the white fuming nitric acid coolant is lowered to a critical level.

Since the combustion efficiency and temperature of the chamber do not drop significantly with chamber pressure, the second stage chamber must still be resistant to the heat rejection rate in the combustion process and have a rather low coolant velocity and pressure.

The thrust chamber is light weight aluminum, constructed of longitudinal tubes preformed to the chamber contour. The 5250 aluminum tubes are joined by welding and wrapped with a square-cross-sectional steel wire to form an integral pressure tight assembly.

This tubular construction permits the circulation of the nitric acid oxidizer through a jacket between the chamber walls. The process is similar to the regenerative cooling in the first stage where kerosene is circulated as the cooling medium.

The single-gimballed, Aerojet General, second stage engine, has a maximum allowable dry weight of 380 lb, and a minimum total-impulse-to-total-weight ratio in vacuum of 238 sec. Minimum specific impulse is 271 lb/sec/lb.

### Second Stage Airframe

The second stage, which contains the basic control systems, is essentially the heart of the entire vehicle. The guidance and attitude reference systems are located just forward of the second stage propellant tanks.

Time limitations in the Vanguard programming necessitated the use of many off-the-shelf items as well as new materials. Stainless steel (410) rolled by Allegheny Ludlum is the basic material in the second stage integral tankage. Research Welding and Engineering Co., Inc.,

*continued on page 14*

## • CALCULATING ORBIT VELOCITY

The "basic arithmetic" for calculating an orbit can be found in any high school physics book. They were fortunately derived before the advent of "security."

A satellite travels in a nearly circular orbit with the center of the earth near the center of the orbit. Any orbiting satellite is continuously falling toward the center of the earth, and with a few exceptions, with the same acceleration as a rifle projectile or a thrown stone. For an object traveling in orbit, the acceleration toward the center of the orbit is, velocity squared divided by radius, or $A = V^2/r$. Since it is our intent to calculate orbital velocity, we may state $V^2 = Ar$. The acceleration, or rate of change of velocity, is 32 ft/sec/sec, or 32/5280 miles/sec$^2$. The radius of the earth is approximately 4000 mi. Substituting in the equation we get $V^2 = \frac{32}{5280} \times 4000 = 24.2$, or $V = 4.9$ mi/sec.

However, there would be too much heat generated on the surface of a satellite to consider an orbit near the earth. If we consider a satellite 350 mi up, using Newton's inverse-square-law of gravity there is a loss in acceleration which may be calculated as $\frac{32}{5280} \times \left(\frac{4000}{4350}\right)^2$ mi/sec. Using this decreased acceleration factor, orbital speed is about 4.7 mi/sec at 350 mi altitudes.

By dividing the circumference of the orbit by the speed, the time for one revolution can be estimated. This is 5800 sec or 96 min.

This over simplification must take into account the fact that orbits are actually ellipses, if accurate calculations are to be made. These relationships were worked out as early as 1619 by Kepler, it was later in the same century that Newton gave mathematical reasons why orbits are ellipses.

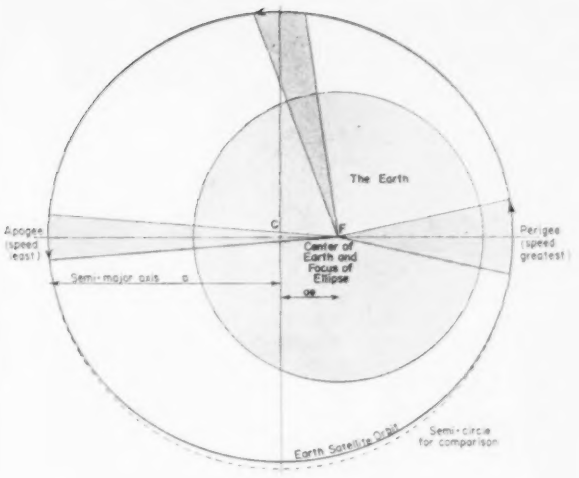



*Fig. 1—This is a typical earth satellite elliptical orbit. The focus F of the ellipse is at the center of the earth. The speed is greatest at position of perigee and least at position of apogee (exact relations can be determined from one of Kepler's laws which states that the rate of sweeping out of area by the radius vector is constant—thus the areas of the three shaded triangles are the same). The eccentricity "e" of this orbit is about twice that presently contemplated for any earth satellite, but even so, the orbit still is almost circular, the center of the ellipse being at "C".*

*There are six elements of an earth-satellite elliptical orbit: its semi-major axis "a", its eccentricity "e", the right ascension of the ascending node (angle seen from the earth's center between the point in the sky known as the vernal equinox and the point where the orbit crosses the equator going north) Ω, the angle of inclination of the orbit to the equator "i", the argument of perigee (angle between the ascending node and point of perigee) ω, and the time of perigee passage "T". The first two define the size and shape of the ellipse, the second two the orientation of the plane of the ellipse, the fifth the orientation in the plane, and the last the time. Implicit as a seventh element is the requirement that the focus of the ellipse be at the earth's center, thus corresponding to the seven data required for specifying an orbit—three position components, three velocity components, and time.*

## VANGUARD PROPULSION DATA

### STAGE I Engine-General Electric Co.

(a) Thrust: 27,000 lb (approx)
(b) Propellants: Kerosene (used as coolant) and liquid oxygen
(c) Burning Time: 2 min (approx)
(d) Ignition: Pyrotechnic squib
(e) Mounting: Gimbal
(f) Propellant Feed: Turbo-pump, powered by $H_2O_2$ decomposition
(g) $H_2O_2$ decomposition "steam" is exhausted through roll-control nozzles
(h) Construction: 4130 steel, double-walled, spiral flow, kerosene-cooled

### STAGE II Engine-Aerojet-General Corp.

(a) Thrust: 7500 to 8000 lb
(b) Propellants: White fuming nitric acid and unsymmetrical dimethyl hydrazine
(c) Burning Time: 2 min (approx)
(d) Ignition' Propellants are hypergolic
(e) Propellant Feed: From helium-pressurized stainless steel propellant tanks
(f) Mounting: Ball-and-socket gimbal
(g) Control during coasting (burnout) period: Small gas nozzles, using remaining helium, exercise pitch, yaw and roll control
(h) Small solid propellant rockets (Atlantic Research Corp.) fire for one second at end of Stage II flight
(i) Construction: Aluminum tube-bundle, welded and wrapped with steel wire

### STAGE III Engine (Solid Propellant)-Grand Central Rocket Co., Allegany Ballistics Laboratory

(a) Thrust: 2800 lb
(b) Burning Time: 20 to 30 sec
(c) Flight Stability: Achieved by spinning unit at 150 rpm (approx)
(d) Throat Lining: Carbon
(e) Rocket Motor: 410 stainless (0.029 in. approx)
(f) Ignition: "Propellant charge" enclosed in restraining tube. 15 sec delay fuse built in to permit spin-up separation of unit. Atmospheric pressure maintained by sealing plug in throat

# Vanguard details revealed

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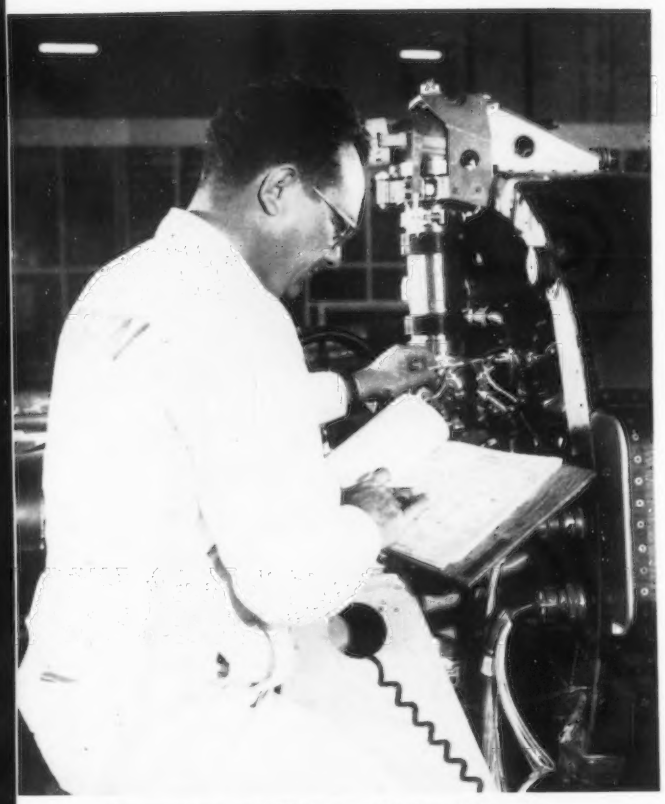
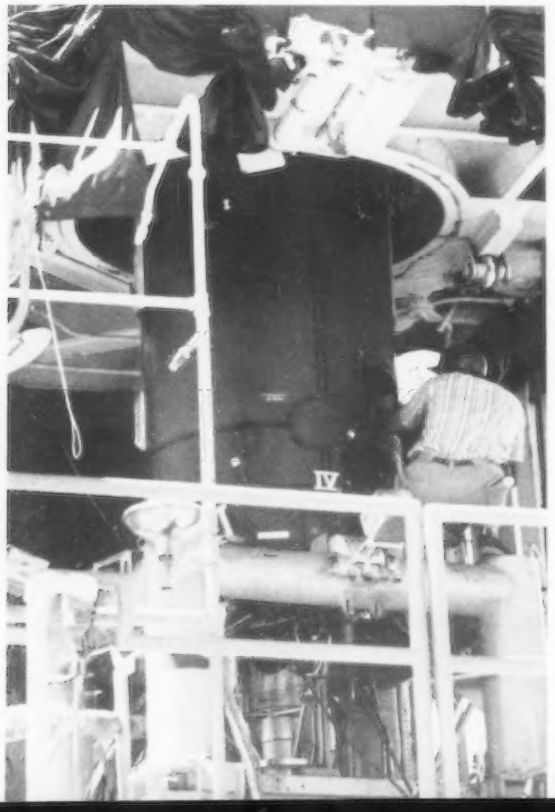


**Connections and fittings on the top of the first stage rocket motor are checked by a Martin technician. Constant direct reference is made to technical manuals to preclude errors.**

Final adjustments are made on the launching pad First stage of Vanguard is shown amid maze of fueling lines and gantry structure.



combined forces with Aerojet General Corp. to fabricate the second stage components. Welding is the major fabrication technique. Construction is similar to that described earlier in the first stage.

### Third Stage

What is called the third stage is actually housed in the second stage airframe. When the third stage motor is fired, it parts from the forward end of the second stage skin and enters the final trajectory phase.

The 6½-ft nose cone of Pyrotex, style 41-RPD (phenolic impregnated asbestos) opens like a clam shell and is dropped shortly after the second stage ignites.

There is no third stage guidance system. It would be too heavy. Instead this stage is stabilized by spinning about its longitudinal axis like a rifle slug at 150 rpm. The satellite must be closely dynamically balanced about its spin axis to stay in the predetermined launch path. Spinning is provided by small PET rockets built by Atlantic Research Corp.

The third stage propellant rocket motor is fabricated of 410 stainless about 0.029 in. thick.

### Testing

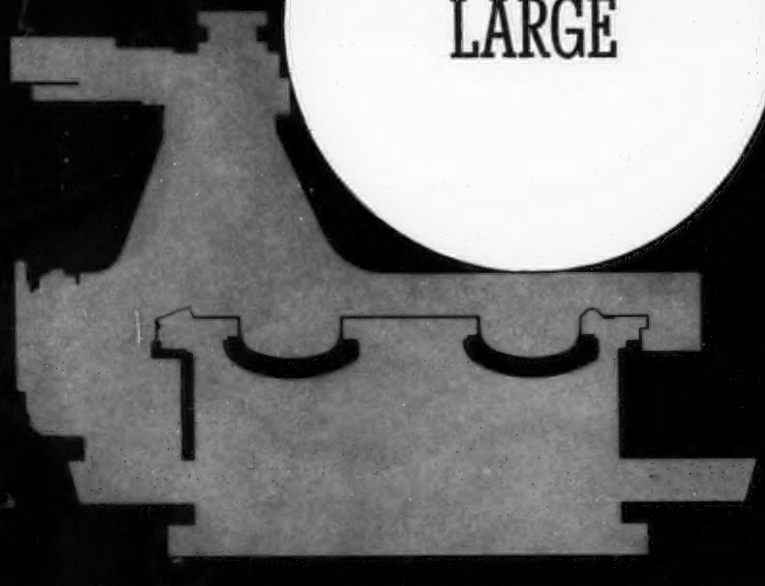
In an effort to decrease delays at the launch pad, The Martin Co., has constructed a vertical test facility about 20 ft deep, 35 ft wide, and 97 ft high at the Baltimore plant. Completed stages of the Vanguard are towed into this test facility and stacked on top of each other simulating the steps to be taken at the launching site. The splice and alignment are checked out with optical tooling to be certain the final centerline of the missile falls within the tight tolerances established. The tip of the 72 ft missile must fall within 0.250 in. of being perfectly vertical with a point at the center of the base. If the optical alignment shows there is an error (one of the three elements being out of plumb), the mating surfaces are reworked.

Subsequent alignment checking is done at the launching site and this is more elaborate. Keuffel and Esser Co. is the supplier of two optical aligners that are used on site.

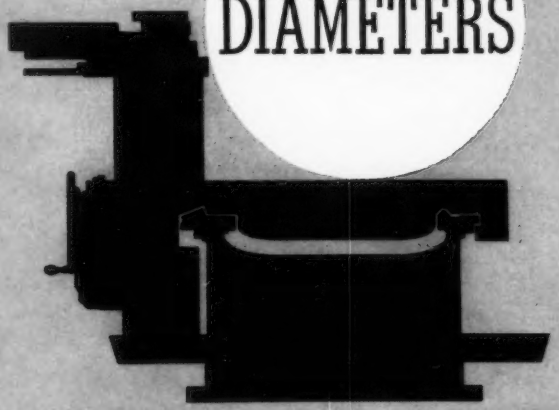
All systems which are checked in a simulated count down at The Martin Co. test facility are retested at Cape Canaveral.

TURNING

LARGE

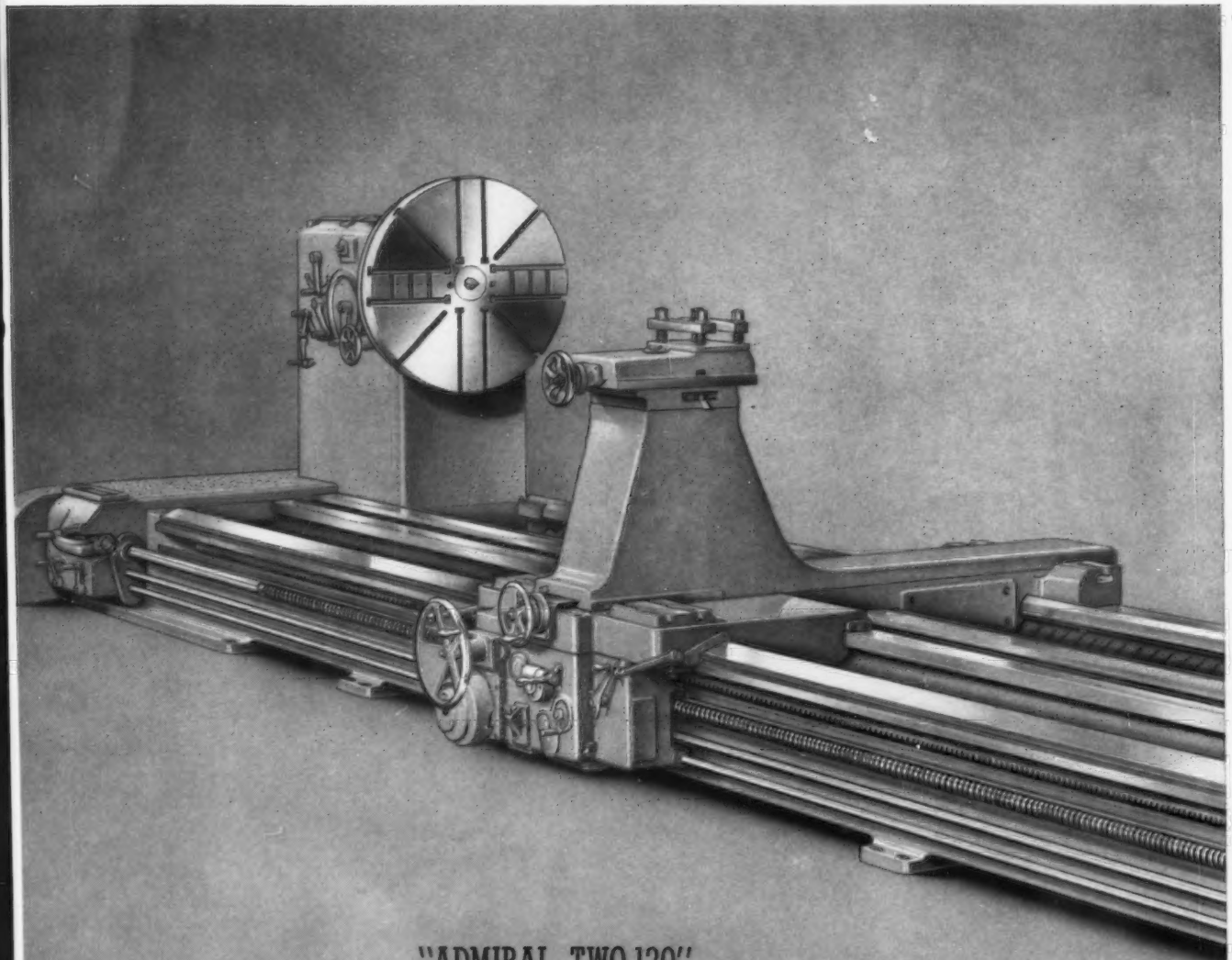


DIAMETERS



On two new LeBlonds

# TWO NEW LEBLONDS



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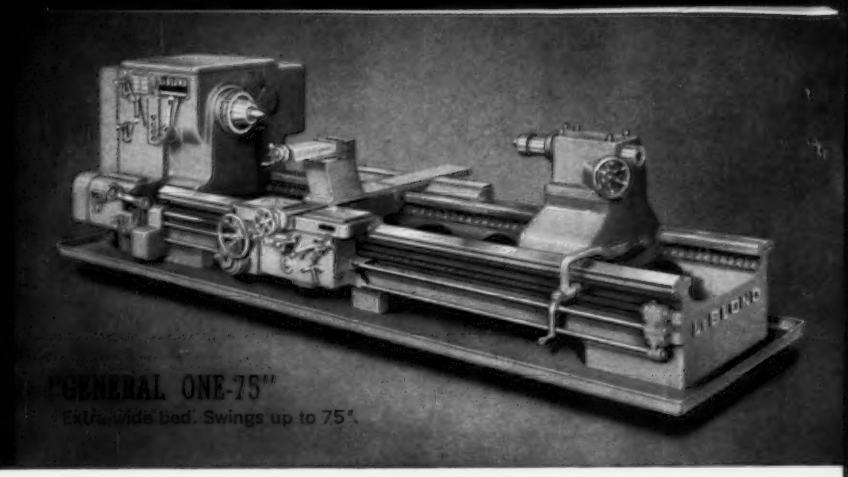
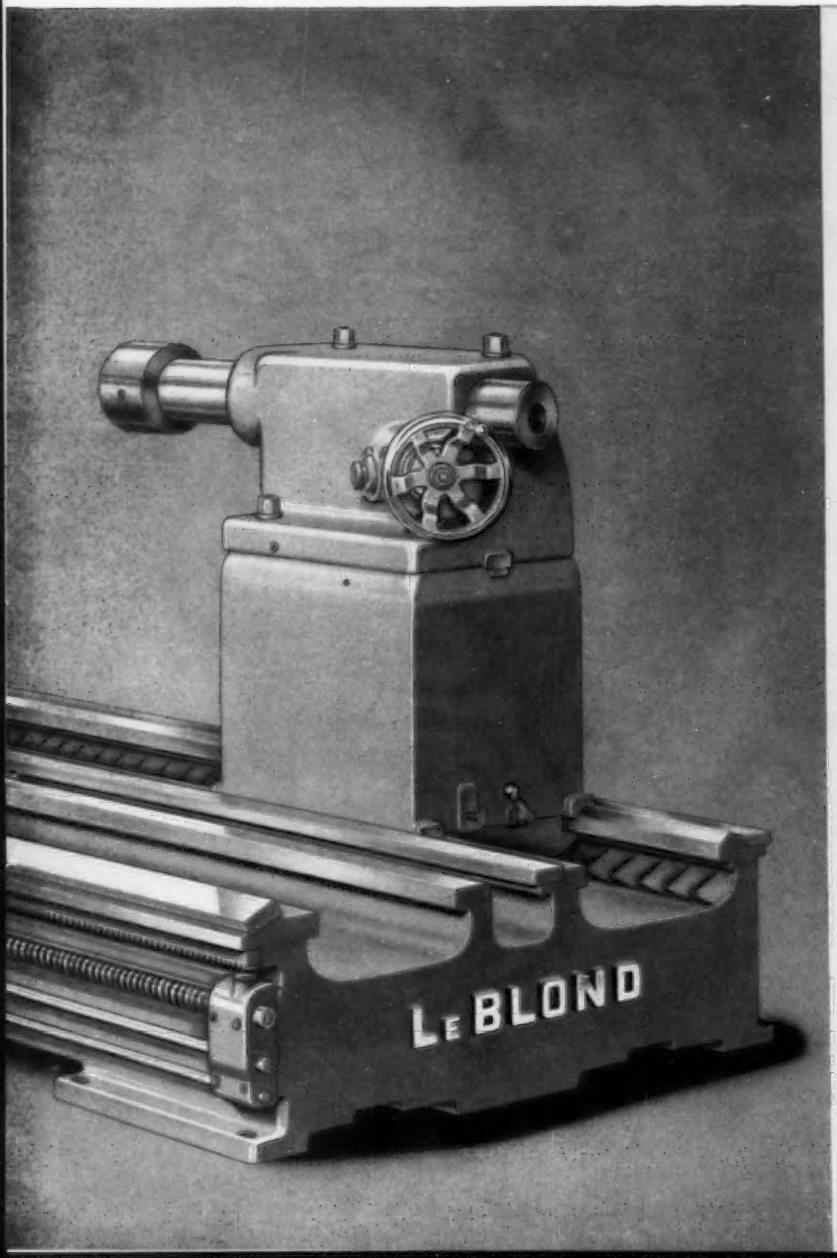



*Missile bodies and other large cylindrical, tubular and fabricated parts . . .*

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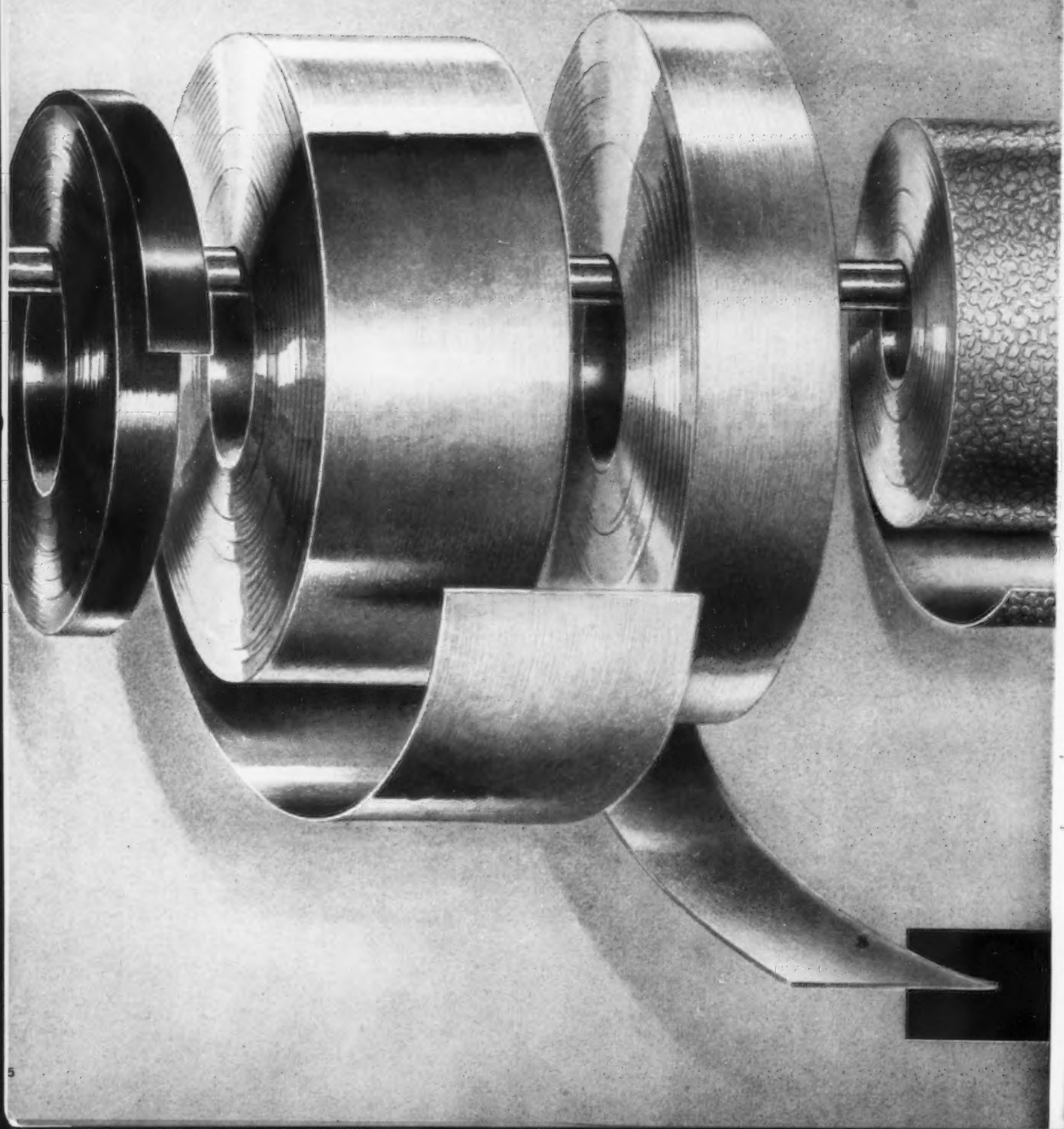

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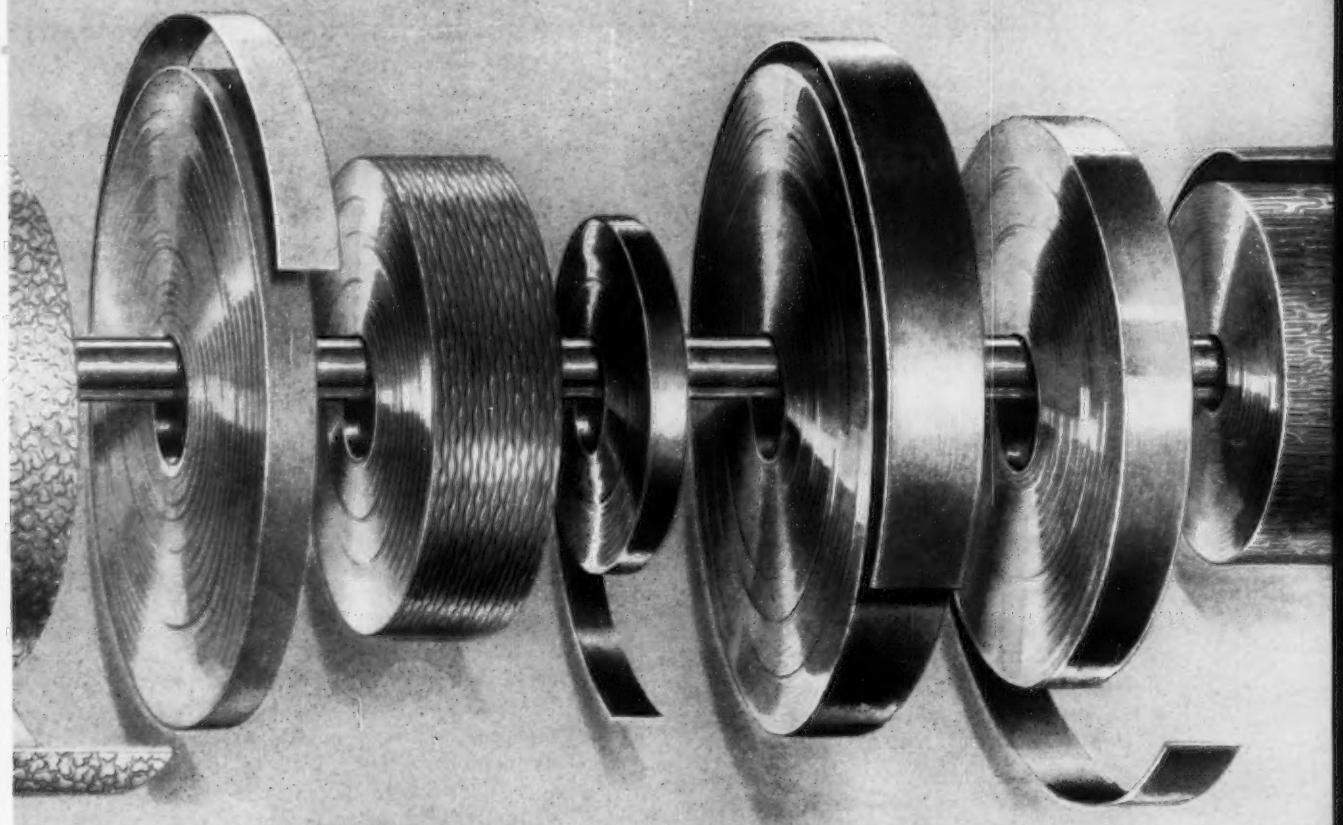

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**tetrafluoroethylene enjoys wide usage in aircraft and missiles, knowledge of material properties essential to designing for specific applications**

# Teflon—high and low

Aircraft and missile parts made of TFE-fluorocarbon resins (Teflon) are resistant to attack from most chemicals and solvents, are mechanically tough, and have good dielectric properties. Many of these properties are retained at temperatures as low as that of liquid nitrogen (—320°F), and at temperatures as high as 621°F, the crystalline melting point of tetrafluoroethylene (TFE).*

The performance of TFE resins at both high and low temperature has been repeatedly demonstrated.

A few examples are:

- Fuel lines for carrying corrosive missile fuels.
- Flexible hose for fuel lines and hydraulic lines which withstands the high and low operating temperatures of jet aircraft.
- Landing skis faced with tetrafluoroethylene resins, used on Air Force polar troop carriers.
- Gaskets used with liquid air at —320°F.
- Packings handling nitric acid at 365°F.
- Pump diaphragms rated for service from —50° to 300°F.
- Lead-through bushings which maintain a tight seal when cycled repeatedly over a temperature range of —85° to 300°F.

TFE-fluorocarbon resins have given satisfactory performance in these demanding uses because the applications were designed correctly. In recognition of the importance of basic engineering data to the design and materials engineer this article is devoted to a description of the mechancial properties of TFE resins at both high and low temperatures.

* Society of Plastics Industry has adopted a standard nomenclature for Teflon, tetrafluoroethylene resins. The common name is "TFE-fluorocarbon resins." The TFE designation is used throughout this article for brevity.

### Tensile Properties

Tetrafluoroethylene remains tough and strong at low temperatures. At —370°F., TFE yields at about the same yield stress as a metal like annealed aluminum. At this temperature, the ultimate elongation at the yield point is about 6 per cent. While this value is substantially lower than the elongation at room temperature, it is adequate with correct design, for many low-temperature applications. A comparison of the low-temperature properties of resins with those of typical light metals is given in Table I. Tetrafluoroethylene is also useful at high temperatures. At 480°F., the yield strength is still more than 25 per cent of the corresponding value at room temperature, a strength retention beyond that of most organic materials.

### Compressive Strength

At low temperatures where tetrafluoroethylene changes from a ductile to a rigid material, the compressive yield stress increases as shown in the accompanying charts.

At room temperature or higher, the plastic nature of TFE becomes evident. Compressive stress decreases with increasing temperature.

For plastic materials such as TFE, design considerations should be based on the yield stress at 1 per cent and 5 per cent strain rather than on ultimate tensile strength. For example, at 1 per cent strain, the yield at 392°F. is 100 lb per sq in. rather than the estimated value of 1,400 lb per sq in. at room temperature.

### Flexural Modulus

The flexural modulus undergoes marked changes with temperature, increasing in value as the temperature decreases. For example, at —320°F., molded or extruded TFE parts, with 60 per cent crystallinity, have a flexural modulus of 850,000 lb per sq in. Flexural modulus value at

# temperature properties

various crystallinity levels, and at temperatures from −88°F. to 482°F., are given in Table II.

### Reinforced Compositions

Both the stiffness of tetrafluoroethylene and resistance to deformation under compressive stress can be increased (by about 500 per cent and 1000 per cent, respectively) by the addition of inorganic additives as reinforcing agents. Common inorganic additives are ground glass fibers, copper, graphite, and coke flour.

TFE resins reinforced with asbestos have high flexural modulus. Compounds of 65 per cent TFE resin and 35 per cent asbestos (by volume) usually produced a maximum flexural modulus and compressive strength.

*continued on next page*

Table I. Comparison of Low-Temperature Properties of TEFLON TFE-Fluorocarbon Resin With Those of Typical Light Metals

| Material | Crystallinity Level, % | Temperature, F | Yield Strength, lb sq in. | Elongation at Yield, % | Ultimate Tensile Strength, lb sq in. | Ultimate Elongation, % | Reference |
|---|---|---|---|---|---|---|---|
| TEFLON Resins | 50 | −321 | 16,300 | 6 | 16,800 | 6-7 | 2 |
| | 60 | −321 | 13,500 | 5 | 14,000 | 5-6 | 2 |
| | 70 | −321 | 10,400 | 5 | 11,000 | 5-6 | 2 |
| | 80 | −321 | 7,200 | 5 | | | |
| Aluminum annealed | — | −292 | 4,500** | — | 20,800 | 44 | 3 |
| hard drawn | — | −301 | — | — | 63,000 | — | 4 |
| Copper annealed | — | −292 | 11,500** | — | 50,800 | 58 | 3 |
| cold drawn | — | −299 | — | — | 64,700 | — | 5 |

** Yield stress at 0.1 percent offset. Values increase as the metal is cold drawn to specified tensile strength.

The above values are intended to provide an approximate comparison and may involve different interpretations of yield strengths (see ASTM Bulletin, May 1952). More exact comparison will require concurrent testing of TEFLON resins and light metal test pieces at equivalent dimensions and testing rates.

Table II. Effects of Temperature and Crystallinity on Flexural Modulus of Elasticity (ASTM D790) of TEFLON TFE-Fluorocarbon Resins

| Crystallinity, % | Flexural Modulus of Elasticity, lb/sq/in. | | | | | |
|---|---|---|---|---|---|---|
| | −88°F | 73°F | 212°F | 302°F | 392°F | 482°F |
| 50 | 210,000 | 45,000 | 26,000 | 7,000 | 2,000 | — |
| 55 | 240,000 | 67,000 | 33,000 | 12,000 | 7,000 | 4,000 |
| 60 | 270,000 | 88,000 | 41,000 | 17,000 | 12,000 | 8,000 |
| 65 | 310,000 | 110,000 | 49,000 | 23,000 | 17,000 | 12,000 |
| 70 | 340,000 | 132,000 | 57,000 | 28,000 | 21,000 | 16,000 |
| 75 | 370,000 | 154,000 | 64,000 | 33,000 | 24,000 | 19,000 |
| 80 | 400,000 | 176,000 | 72,000 | 38,000 | 27,000 | 22,000 |

### Impact Strength

The impact-resistance of molded parts at sub-zero temperatures is good.

Some typical Izod impact strength values (ASTM D256-47T) follow:

| Temperature, °F. | Impact Strength, ft lb/in. |
|---|---|
| −70 | 2.0 |
| 73 | 3.0 |
| 170 | 6.0 |

### Thermal Expansion

Like most organic materials, TFE expands, to a greater degree on heating than metals.

Molded TFE parts contract 2 per cent when cooled from room temperature to −325°F. An expansion of 4 per cent takes place when the parts are heated from room temperature to 480°F.

The use of reinforcing agents tends to reduce the coefficient of linear thermal expansion. For example, a TFE-fluorocarbon resin reinforced with about 25 per cent graphite additive (by volume), will have a coefficient of expansion about half that of an unmodified TFE resin. Other additives can reduce the coefficient of expansion even further.

### Effects of Fabrication

The most significant variables affecting the properties of a part molded or extruded from TFE resin are crystallinity and void content. These factors can be readily controlled by competent molders and extruders.

Two variables control crystallinity. The major factor is the molecular weight of the particular TFE resin.

The other variable is the rate at which a sintered piece is cooled from 620°F. to 575°F. The effect of cooling rate on crystallinity is shown in Table III.

In thin sections (less than ⅛ in.), the entire piece can be cooled rapidly to obtain a low crystallinity. In the case of thicker sections, the inner material is insulated by the outer skin and cannot be cooled rapidly.

An indication of the cooling rates that can be obtained practically is given here:

| Method of Fabrication | Practical Cooling Rate Range | Typical Crystallinity Range |
|---|---|---|
| Molding | Quenching to 45°F./hr | 49 to 57 per cent |
| Ram Extrusion | Quenching to 45°F./hr | 50 to 57 per cent |
| Paste Extrusions* | | 50 to 55 per cent |

** Thin insulation is applied to wire by this process, and is always quenched.*

In most applications, a low crystallinity is desirable. Flexural modulus and impermeability are the only properties that are improved appreciably with an increased crystallinity. Flex fatigue life, tensile strength, impact strength, and elongation at yield are improved markedly with a low crystallinity.

The presence of voids or microscopic flaws also affect the yield strength and elongation. They are especially harmful at low temperatures.

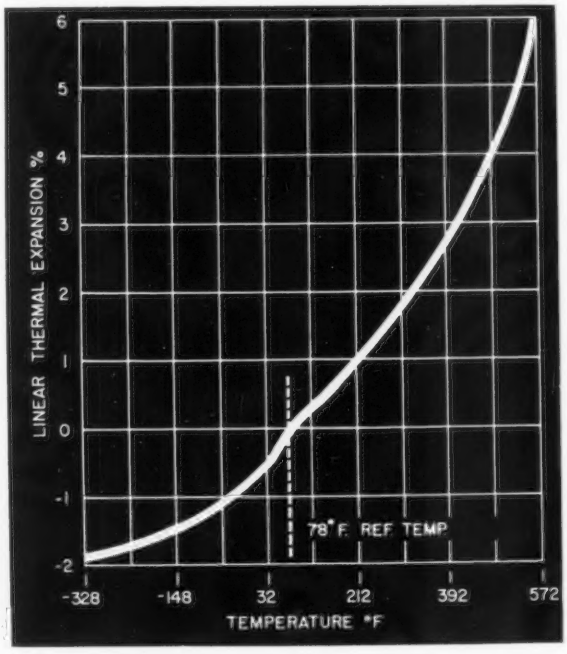
Shapes made by the paste extrusion process show varying degrees of differences in longitudinal direction that it is in the transverse direction. The difference may be as high as 20 per cent with the strength in the transverse direction being less.

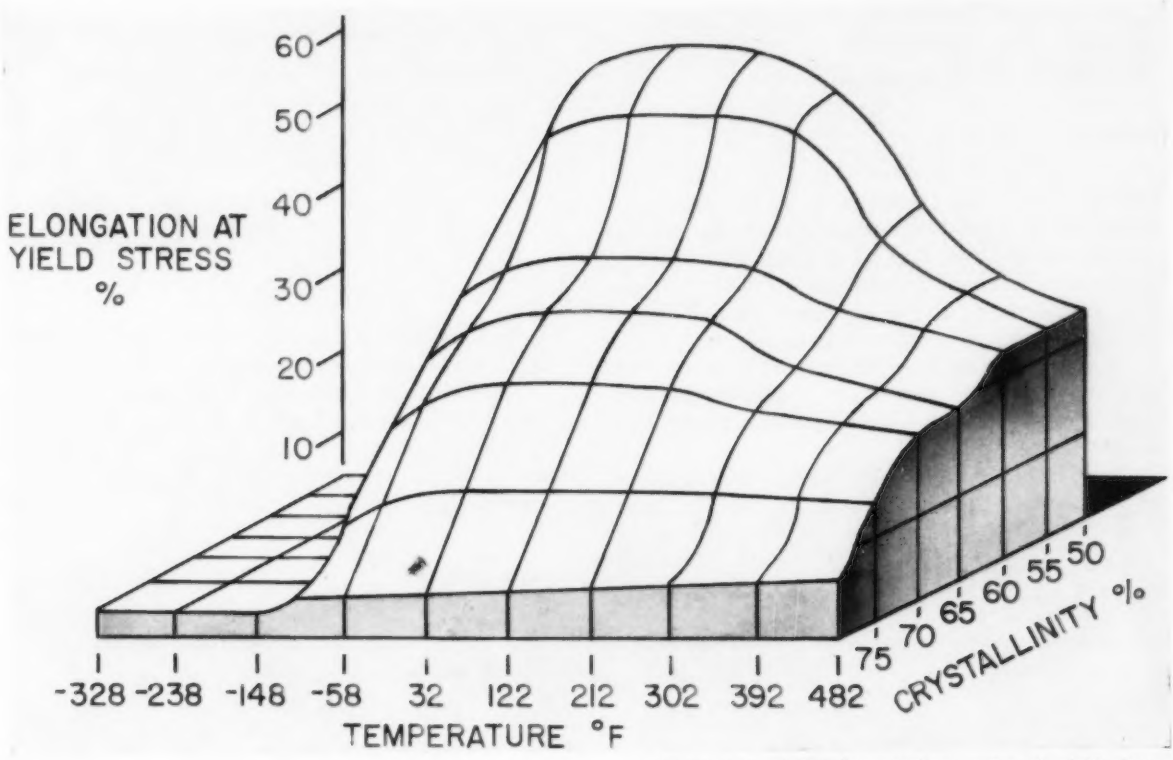
*continued on page 24*

**Table III. Effect of Cooling Rate on Crystallinity of Molded or Extruded TEFLON TFE-Flurocarbon Resins**

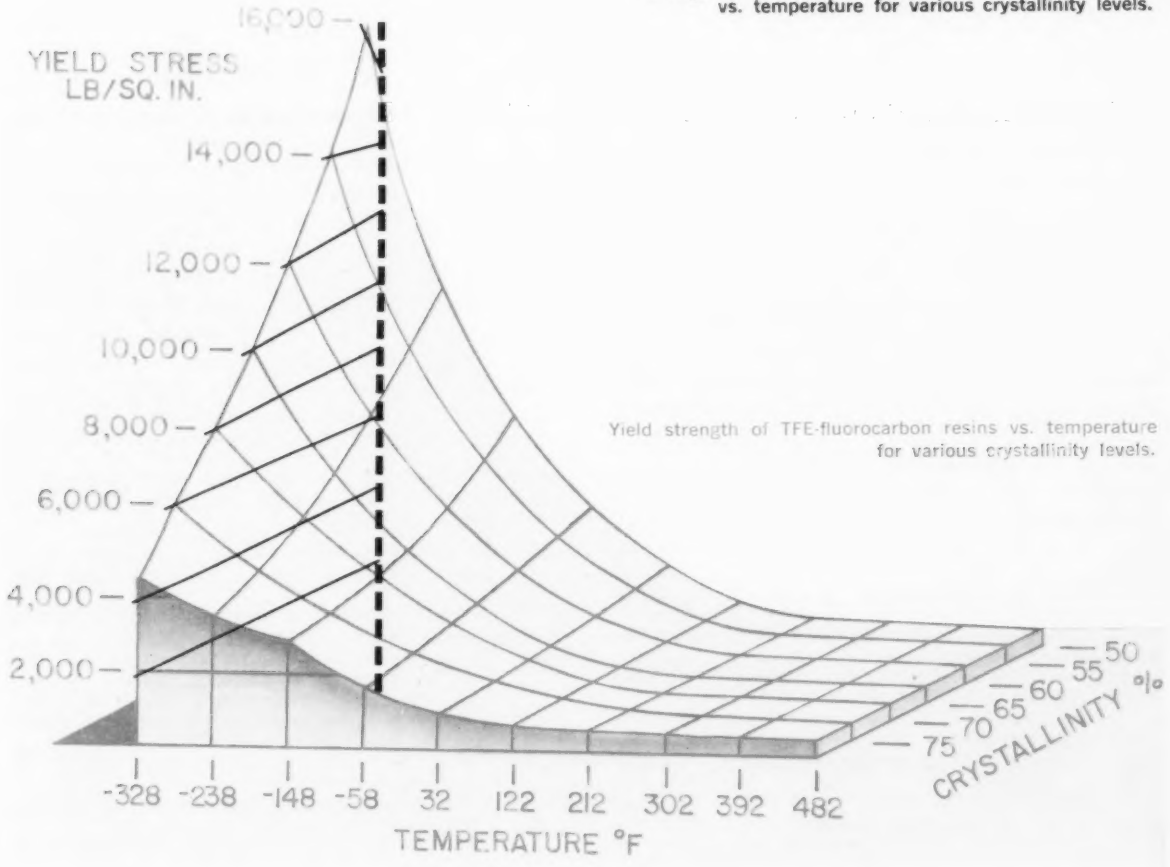
| Cooling Rate, °F./hour | % Crystallinity TEFLON 1, 5, 7X | TEFLON 6, 30 |
|---|---|---|
| Quenched in ice water | 44 | 50 |
| 540 | 54 | 65 |
| 108 | 56 | 72 |
| 54 | 58 | 74 |
| 10.8 | 62 | 78 |

Linear thermal expansion of TFE-fluorocarbon resins at 54 per cent crystallinity.






**Elongation of TFE-fluorocarbon resins at yield stress vs. temperature for various crystallinity levels.**




Yield strength of TFE-fluorocarbon resins vs. temperature for various crystallinity levels.

# Teflon continued

### Practical Implications

As has been shown, molded TFE-fluorocarbon resins will maintain a useful degree of flexibility at very low temperatures. In designing an article to be used at a given temperature, the designer should take into account the elongation at yield point at this temperature, and should not exceed this in service or installation.

Consider the case of a piece of tubing with one end fixed and the other end attached to a cycling or vibrating piece of equipment operating at low temperatures.

The maximum permissible displacement of small-sized tubing for lengths ranging from 6 in. to 4 ft at various temperatures are shown in the table above. Beyond the indicated displacement, permanent set may result.

**Permissible Displacement of Tubing**

| Length of Tubing, feet | Maximum Displacement, in. | | |
|---|---|---|---|
| | at −320°F. | at −112°F. | at −40°F. |
| 0.5 | 1 | 1½ | 3¼ |
| 1.0 | 2¼ | 3⅛ | 6½ |
| 2.0 | 4½ | 6¼ | 13 |
| 4.0 | 9 | 12½ | 26 |

The table is derived from simple calculations and is based on a safety factor of 2½. These figures indicate that in the range between −½°F. and −40°F. the permissible displacement increases significantly.

**Table IV. Effects of Crystallinity and Temperature on Yield Strength of TEFLON TFE-Fluorocarbon Resins (ASTM D638-52T)**

| Crystallinity, % | Yield Strength, lb/sq/in. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | −321°F | −112°F | −40°F | 73°F | 212°F | 302°F | 392°F | 482°F |
| 50 | 16,300 | 5,500 | 3,800 | 1,900 | 1,200 | 950 | 760 | 700 |
| 55 | 13,500 | 4,600 | 3,200 | 1,800 | 1,140 | 860 | 710 | 600 |
| 60 | 11,000 | 4,200 | 2,800 | 1,600 | 1,080 | 800 | 670 | 520 |
| 65 | 9,200 | 3,600 | 2,400 | 1,400 | 1,040 | 750 | 610 | 480 |
| 70 | 7,800 | 3,500 | 2,300 | 1,300 | 980 | 700 | 550 | 440 |
| 75 | 6,000 | 2,900 | 2,100 | 1,200 | 920 | 650 | 490 | 390 |
| 80 | 4,400 | 2,800 | 1,600 | 1,000 | 830 | 560 | 430 | 340 |

(1) $CaF_2 + H_2SO_4 \longrightarrow H_2F_2 + CaSO_4$
(FLUORSPAR) (HYDROGEN FLUORIDE)

(2) $H_2F_2 + CH_3CL \longrightarrow CHClF_2 + 2HCL$
(CHLOROFORM) (CHLORODIFLUOROMETHANE)

(3) $2CHClF_2 \xrightarrow{\text{PYROLSIS}} CF_2CF_2 + 2HCL$
(TETRAFLUOROETHYLENEMONONER)

(4) $n \left[ \begin{matrix} F & F \\ | & | \\ C & = & C \\ | & | \\ F & F \end{matrix} \right] \xrightarrow[\text{PRESSURE}]{\text{HEAT}} \left[ \begin{matrix} F & F & F & F & F \\ | & | & | & | & | \\ -C & - & C & - & C & - & C & - & C & - \\ | & | & | & | & | \\ F & F & F & F & F \end{matrix} \right]_X$
TEFLON

## WHAT TEFLON IS

Teflon is a member of the fluorocarbon family. While classed as a thermoplastic resin, it does not melt and flow as do conventional materials in this class. It has a crystalline structure at normal temperature, but when heated above 620°F, changes to amorphous gel.

In the gel phase Teflon will not flow, and only limited deformation can be achieved without fracturing the gel. Processing techniques consist of a cold-forming operation followed by baking or sintering at 650 to 720°F, where coalesence takes place and the particles are "welded" into a single mass.

Teflon is manufactured by reacting calcium fluoride (Fluorspar) and sulfuric acid to give hydrogen fluoride. This in turn is reacted with chloroform to give chlorodifluoromethane, which is converted by pyrolysis to gaseous tetrafluoroethylene monomer. Polymerization of the monomer is effected at high temperatures and pressures.

The polymer is a long straight chain of atoms packed together closely. This structure and the strong chemical bond between the carbon and fluorine in the molecule give the good resistance to heat and chemicals.

TFE-fluorocarbon resin is produced in the basic forms of powder and aqueous dispersion. Powders are used in molding and extrusion processes, the aqueous dispersion is used in coating, filmcasting, and impregnating.

Because of the extreme degree of chemical inertness shown by TFE there is no adhesive which will bond two pieces of Teflon to give mechanical properties in any way approaching the base material. Teflon can be bonded to other organic materials.

The various grades of compounds available are:

Teflon 1—General purpose granular molding powder.

Teflon 5—Molding powder, specially granulated for molding cylinders for shaved tape.

Teflon 6—Fine powder for use in extrusion of wire insulation and thin-wall tubular goods.

Teflon-7X—Special purpose ultra-fine molding powder for use in molding shapes and cylinders for shaved tape.

Teflon 30—Aqueous dispersion containing 60 per cent solids by weight.

Teflon 41X—Aqueous dispersion containing 33-35.5 per cent solids by weight.

Teflon 100X—Extrusion powder, experimental, can be melt processed.

# turbine blades produced automatically

**continuous-process machine at Marman converts roll stock into finished blades at high rate**

by
W. M. Willis
engineering manager
Marman Div. Aeroquip Corp.

A fully-automatic machine producing stator blades is now in operation at Marman Div., Aeroquip Corp., Los Angeles. This machine produces blades at the highest rate yet envisioned by aircraft gas turbine planners.

Current production involves blades using British-produced Nimonic 75 alloy, but the machine is capable of producing blades from virtually any metal, including titanium. It is not restricted as to blade contour or dimension; its automatic electronic inspection system can be used to control blade tolerances upon demand.

Roll stock is fed into the input end of the machine, which is arranged as a single, continuous process line. The stock passes through a series of radial forming rolls which progressively produce the finished contour of the blade. The strip then moves into a series of vertical rolls which successively close the strip into the final blade contour.

The strip then moves into the specially-designed Sciaky welding machine, which produces a continuous and homogenous resistance weld between the closing edges of the blading. This continuity overcomes the reputed intermittent character of conventional "seamless" welding, which is effected at a cycling rate. The new system is an exclusive Marman development.

After welding, the formed blade passes through a belt-grinding stage, followed by stages of roughing, finishing and polishing operations. The trailing edge is then milled, and the blade passes through an electronic gaging system, which provides continuous, accurate inspection of the blade overall contour within $\pm 0.0001$ in., through a series of 16 feelers. These feelers act as pickups for comparison networks within the control system. The appearance of any inaccuracy flashes on a warning light, which alerts the lone operator of the machine to the precise location of the fault. He then adjusts the portion of the machine producing the error and the operation is resumed.

The strip is cut into individual blades by an Anocut machine, whereby the material being removed is stripped away by electrolytic action. The part and cutting head are immersed in an

*continued on next page*

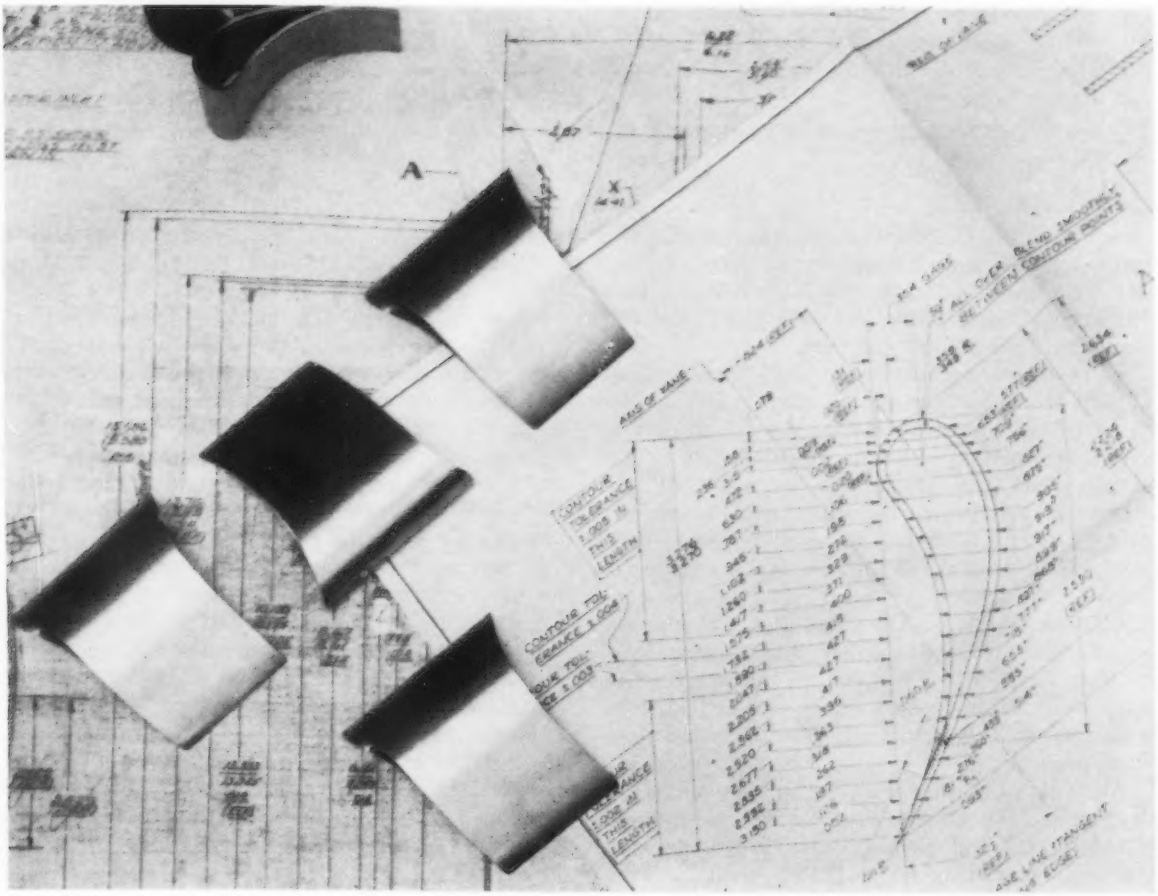
electrolytic bath; the part acts as the anode, and the cutting head as the cathode. The part is thus severed through decomposition of the material rather than conventional contact between cutter and work.

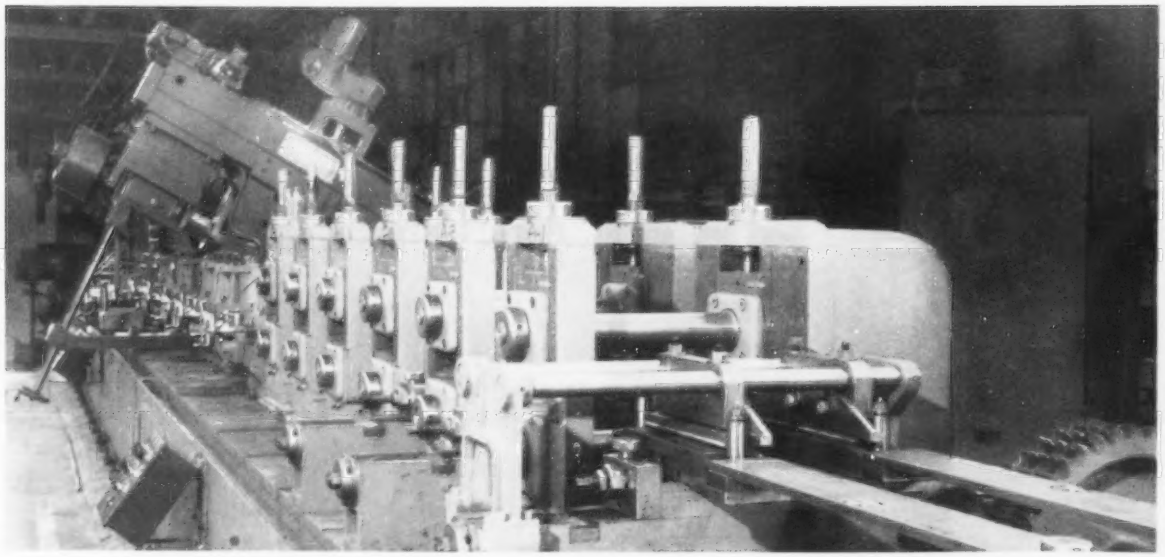
The Marman automatic blade machine utilizes a feed rate of 12-18 in./min, and produces complete blades at a rate of 150-250/hr, depending upon blade size.

Conventionally welded blades suffer from the inherent contrast between the material of the wrought blade and that of the case weld. This tends to produce a difference in resonance between the two, hence fatigue failure. The homogenous welding method produces a completely wrought unit without discrepancy in stress characteristics between blade and weld. Elimination of dies, hand finishing, and individual handling promises savings to aircraft gas turbine manufacturers and users upwards of 75 per cent of total blading costs projected throughout the life of the engine.

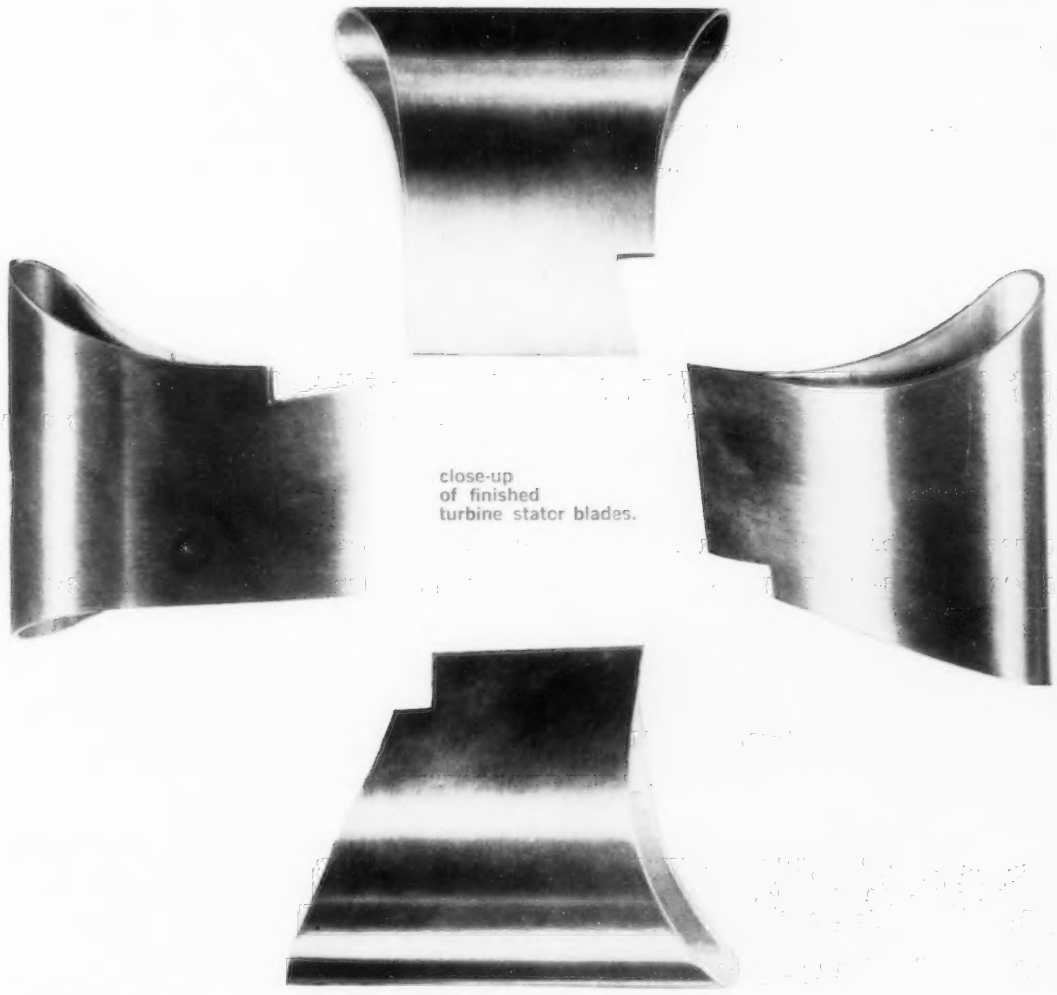
The versatility of the new machine is also illustrated by its capacity to produce the electrodes used for cutting the matching stator blade cavities in the stator housing. Insertion of the stator blade into the ring requires a high-precision fit, which is insured by using identical blade coordinates for the process. Cavities are cut into the ring by the Elox process, which performs an internal stripping or de-plating operation through rapid electrolytic action.

**Design features of stator blades are controlled through station-by-station tolerances.**





**Marman-developed continuous-process machine performs severing, bending, welding, and inspection operations in rapid succession.**



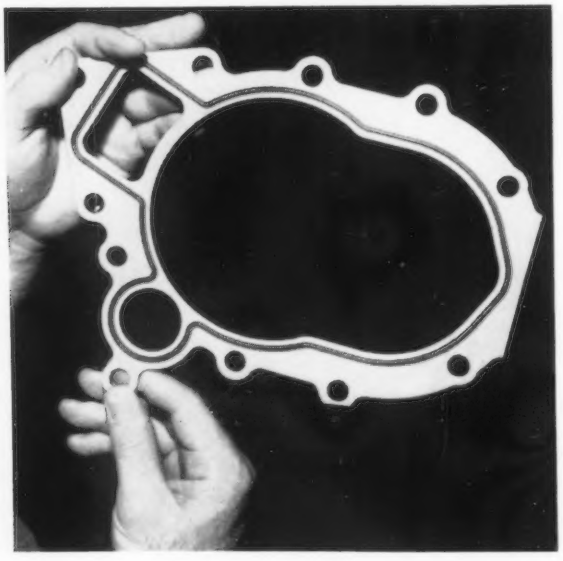
close-up
of finished
turbine stator blades.

Laboratory technician inspects a sheet of "Viton" synthetic rubber. As shipped to fabricators, Vitron is a translucent, light-colored gum.

# fluoroelastomer

**new material for designers arsenal extends uses of elastomers above 400°F; compression set, and resistance to solvents good**

Viton synthetic rubber has found applications in the aircraft industry where resistance to oils, fuels, and solvents at high temperatures is required. This molded-in-place gasket manufactured by Parker Seal Company, a division of Parker Hannifin, Inc., is designed for 200 psi service with JP4 and JP5 at operating temperatures ranging from —60 F to 350°F.



Temperatures are going up; the lists of materials capable of coping with them are dwindling. The search for new materials capable of operating in the high temperature environment is proceeding at a frantic pace.

In the search to extend the useful operating temperatures of elastomers to the super-sonic and hyper-sonic environs, materials men turned to certain polymerized fluorinated olefins. The result was a compound which combines the compressibility of elastomers with the good heat resistance of the fluorocarbons. It contains about 65 per cent fluorine by weight, and is known by the trade name Viton.

The most valuable properties of the fluoroelastomer are:

- Good performance at temperatures of 400°F.
- Resistance to most lubricants, fuels, and hydrocarbons.
- Good mechanicals for an elastomer, but excellent for one so resistant to heat and solvents.

## Properties

Tensile strength is affected only very

slightly by dry heat, when oven aged in air, Viton's vulcanizates remain usefully elastic for more than 2400 hr. at 400°F (test terminated).

Vulcanizates of the fluoroelastomer are also resistant to most of the new aircraft gas turbine fuels, lubricants and hydraulic fluids. Its performance in contact with these fluids is reported by the manufacturer as being unexcelled by any other commercial elastomer at 400°F.

The Viton rubber can be made in any hardness from 60 to 95 durometer.

Tensile strength at room temperature is the range of 2000 to 3000 psi, ultimate elongation varies from 100 to 400 per cent depending on the hardness. These values may be considered fair-to-good for most elastomers and rather exceptional for one which offers the additional properties of high resistance to heat and fluids.

Like all known elastomers, Viton loses some of its tensile strength and elongation at elevated temperatures. With test specimens, heated to and tested at 300°F, tensiles were 300 to 1000 psi and elongations were 80 to 200 per cent.

Resistance to compression set even at high temperatures is one property which might make it extremely useful as a gasket material. Materials engineers sometimes recognize resistant to compression set as a more valuable mechanical property than tensile strength. Specimens compressed 25 per cent and held 70 hr. at 250°F recover to within 90 to 97 per cent of the original dimension.

The low temperature properties of Viton are not outstanding, they are however adequate for most elastomeric applications. Brittle point is affected by specimen thickness. Typical specimens have a Young's modulus of 10,000 psi at −20°F and a brittle point of −47°F. The −47°F value was obtained on a specimen 0.075 in. thick; a thinner specimen (0.025 in.) would have a lower brittle point (−60°F). A 0.010 in. wire coating does not crack at −90°F when bent around a mandrel 10 times the wire diameter.

Compositions of the fluoroelastomer were shown to be resistant to deterioration by ozone for 28 days; other samples have been stretched and exposed to sunlight for 12 months without showing cracks. Resistance to sun and ozone however can only be considered bonus properties since the lower cost of other sun and ozone resistant elastomers precludes the use of Viton if these are the only properties an application demands.

Electrical properties restrict this fluoroelastomer to low voltage, low frequency applications. Typical values are: dc resistance of 2.5 x $10^{13}$ ohm-cm, specific inductive capacity of 16.7, power factor of 4.5 per cent, and a dielectric strength of 412 volts per mil.

## Applications

Seals for military aircraft were considered the main application in the early phases of Viton's development. There is a growing interest in other kinds of products, such as hose, protective clothing fuel cells, wire insulation, caulking, and paint.

VALVE STEM SEALS for reciprocating engines is an application under evaluation. Temperature of the air in the valve cover is 325 to 350°F; temperature of the rubber seal much higher. The valve train is lubricated by oil spray so the seal is bathed in oil.

BRAKE CUPS are another application. Brake temperatures on high performance aircraft appear to be rising beyond the point that materials technology is able to cope with. This is evidenced by recent renewed attempts to build an efficient liquid cooled brake. The fluoroelastomer can stand the combination of heat and hydraulic brake fluid.

FUEL TANKS, either conventional bladder type, or caulking and liquid coating for integral tanks are envisioned applications. Viton will stand immersion in aircraft fuel and will be unaffected by the high aerodynamic skin temperatures generated at Mach 2+.

AIRCRAFT TIRES are even becoming the victims of high temperatures generated on the skins of high performance aircraft. The wheel wells absorb enough of this heat to accelerate the deterioration of the tires. Fluoroelastomers may plug a gap between ordinary tires and airconditioned wheel wells.

A major deterrent to wide use is that Viton is expensive—about 40 times the cost of conventional elastomers.

The chemical compound which forms the backbone for the fluoroelastomer is Viton A. Its composition is represented by the following formula:

$$\left(CF_2\text{—}\underset{\displaystyle CF_3}{\underset{|}{CF}}\text{—}CH_2\text{—}CF_2\right)_x \left(CH_2\text{—}CF_2\text{—}CH_2\text{—}CF_2\right)_y$$

There are two general purpose formulations of the following composition:

| | Parts by Weight | |
|---|---|---|
| **Material** | **Formulation 1** | **Formulation 2** |
| Viton A | 100 | 100 |
| Zinc Oxide | 10 | — |
| Dibasic Lead Phosphite | 10 | — |
| Magnesium Oxide | — | 15 |
| Carbon Black | 25 | 25 |
| HMDA-Carbamate | 1 | 1 |

# these nuts can be replaced in

# 5 SECONDS!

## with NUTT-SHEL'S New TIME

### A PRIME WEAPONS SYSTEM CONTRACTOR SAYS:

"Three per cent of all plate nuts must be replaced, due to installation damage. Cost records show that it takes two men 10 minutes each to replace a conventional plate nut. When we switched to Nutt-Shel's new replaceable nut line, it took one man only 5 seconds for replacement."

This new Nutt-Shel line effects even greater time and cost savings during subsequent servicing and maintenance of any weapons system.

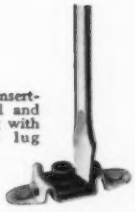
# HERE'S THE 5 SECOND METHOD

1

Insert removal tool, with downward pressure, between nut and shell, as shown. Lean tool against nut barrel to insure engagement.

2

Maintain downward pressure. Nut will snap out easily with a simple prying motion.



3

Install new nut by inserting one lug in shell and striking opposite lug with screwdriver. This lug snaps into place.

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If you haven't tested the TIMESAVER nut, write today for demonstration plate and tool. Convince yourself how fast and easy it is to replace a Nutt-Shel TIMESAVER nut. Write today on your letterhead.

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| **Light Weight** | As light or lighter than anything available. |
| **Accepted** | Meets latest military requirements. |
| **Available** | Available in all popular thread sizes, we ship from stock. |

**Only One Inexpensive Removal Tool Is Needed**

Only one inexpensive removal tool, (in two sizes) is needed, to handle the five most used thread sizes in the nine styles of self-locking nuts in the TIMESAVER line. This procedure may be repeated as often as necessary without impairing performance. The same nut element is used, and may be replaced, in *all* standard styles. Even the spacer nuts are interchangeable. This is not only a convenience for you; it means a reduction in your stock problems.

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# SAVERS

Circle 37 on Inquiry Card, page 85

# reliability . . . keynote of Redstone engine

## double-wall, regeneratively-cooled thrust chamber and improved fuel-injector plate pioneered by Rocketdyne

by Robert McLarren

The rocket engine that placed America's first satellite into orbit was not the most powerful, the most efficient, or even the most advanced ever developed; but, it is one of the most reliable liquid-propellant rocket engines produced to date. All of the elaborate research, development, production and test facilities of Rocketdyne Division, North American Aviation, Inc., Canoga Park, Calif., have been committed for four years to one objective: a completely reliable rocket engine for the nation's ballistic missile program. Nearing their goal, Rocketdyne engineers report that the Redstone engine, both in test and in operational service, currently displays a reliability of 99 per cent.

Rocketdyne has used the static test stand as its major weapon in the pursuit of reliability, and to this end, its multi-million-dollar Santa Susanna Propulsion Field Laboratory has consumed millions of gallons of fuel, as well as the continuous output of a liquid oxygen manufacturing plant on this site.

### Development History

The Redstone engine had its beginning in 1947 when North American Aviation received from Army Ordnance a captured V-2 engine for study, with an Army invitation to suggest improvements in its design and manufacture. North American's original 1946 proposal for the Navajo surface-to-surface guided missile incorporated an engine along the general lines of the V-2 for its booster thrust. The result was an Air Force contract for design and development.

The first Rocketdyne engine, so completely redesigned from the V-2 as to comprise a truly new engine, was tested in 1950; the production engine went into service in 1952. The multitude of separate components of the complex German product had been reduced substantially, its 56,000 lb thrust increased to 75,000 lb. Its range, as well as its thrust-to-weight ratio improved by 50 per cent. More significantly, the notoriously poor reliability of the original weapon (never more than 70 per cent) was improved to the near-perfection point.

The Rocketdyne engine exhibits major design improvements in the following areas:

- Fuel-injection system
- Turbine wheel and pump
- Turbine inducers and impellers
- Fuel and combustion-chamber pressures

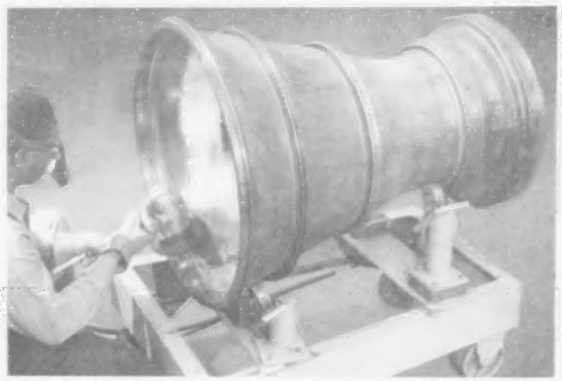
Laborious detail-design improvements with progressively increasing efficiencies have been the major contribution of Rocketdyne.

### Propulsion System

The Redstone missile uses alcohol fuel and liquid oxygen for propellant; these must be pumped into a thrust chamber under high pressure and at very high flow-rates to develop the required impulse. This pumping is accomplished by a steam-driven turbine, on a common shaft with two turbine pumps. The steam is generated

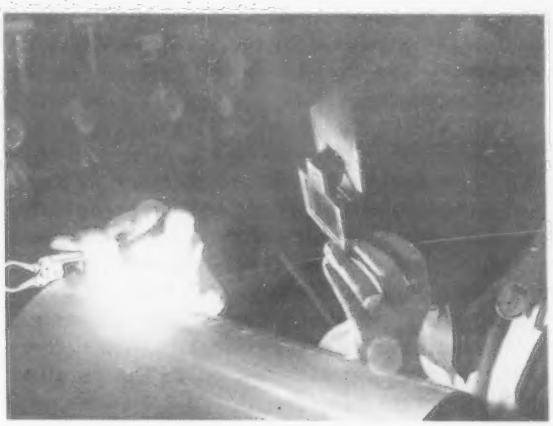
*continued on page 34*

Static test of Redstone engine at Rocketdyne's Propulsion Field Laboratory near Los Angeles.

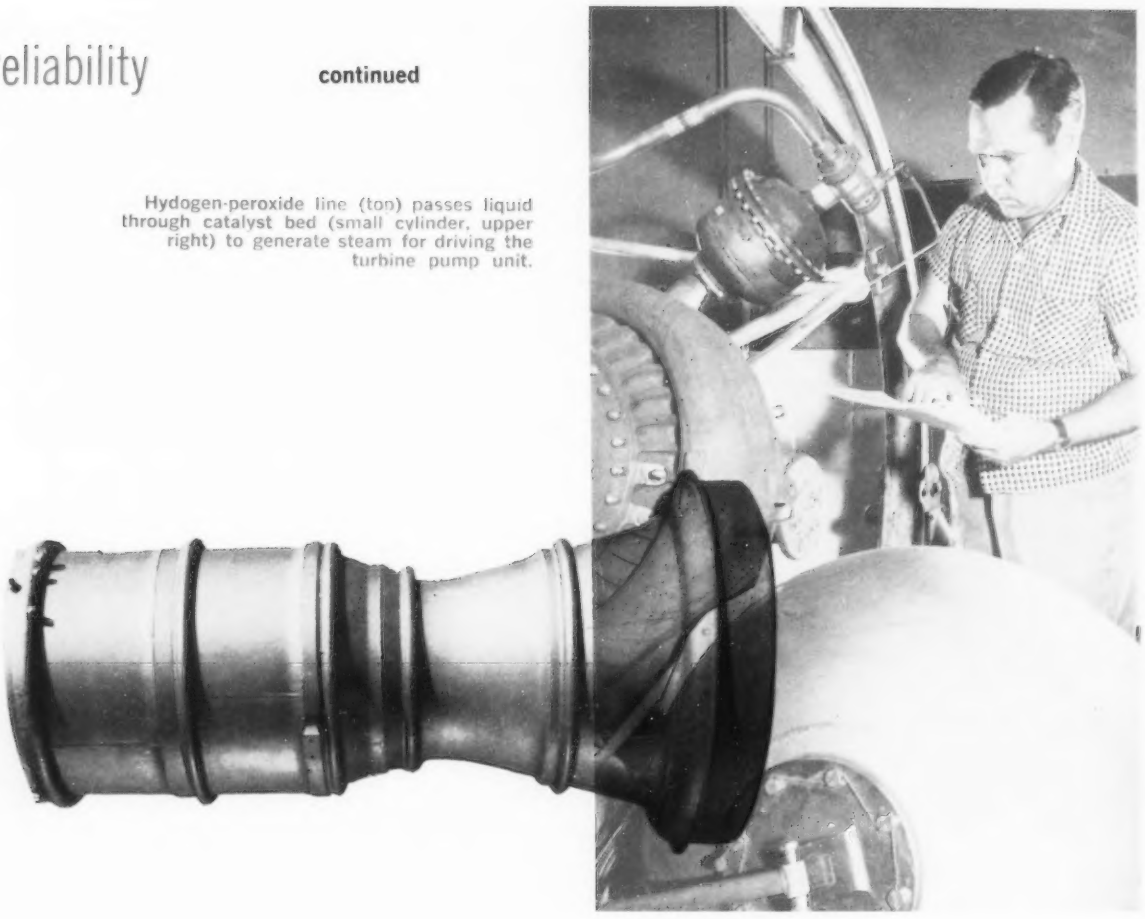


Grinding interior of Redstone thrust chamber in Rocketdyne's East Los Angeles assembly plant. Holes seen in outer rings are to allow passage of fuel for regenerative cooling.

Welding of outside wall on thrust chamber. Circulation of fuel between inner and outer walls serves to cool walls of thrust chamber



Aluminum tube being welded will become the outer wall of a heat exchanger used on the Redstone engine.



Hydrogen-peroxide line (top) passes liquid through catalyst bed (small cylinder, upper right) to generate steam for driving the turbine pump unit.

by the passage of hydrogen-peroxide through a silver screen; the silver acting as catalyst for the decomposition. After passing through the turbine wheel, the steam is carried by a duct to a thrust nozzle, thereby providing additional thrust for the missile.

The liquid oxygen is pumped directly into the injector of the engine. But, the alcohol is pumped into a circumferential manifold at the exit of the thrust chamber, and then back up through the double-wall passages to the inlet manifold, where it enters the fuel injector. This regenerative system enables the fuel to cool the thrust chamber.

### Thrust Chamber

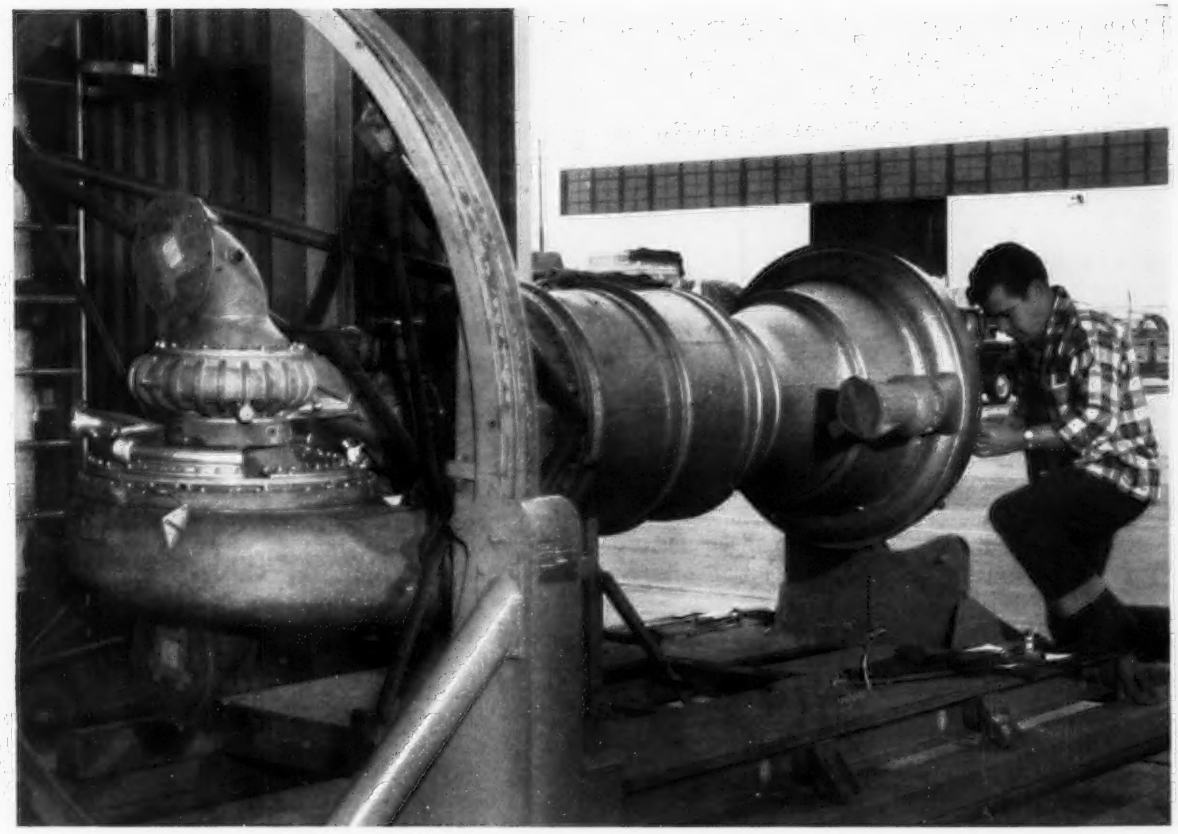
The double-wall thrust chamber is made up of a constant-diameter combustion section and a Venturi-shaped nozzle section. The combustion end is fabricated from 4130 steel plate, formed on a power brake into a tube, and welded along a vertical seam and along circumferential seams. The nozzle region of the chamber is welded from 4130 steel plates stretch-formed to the required double-curvature contour.

The double walls are separated by spacer rings machined from rough billet forgings. The fuel passes through hundreds of drilled holes in these rings under high pressure. The fuel-flow path provides free circulation throughout the area between the walls. Welding is accomplished by the "Union melt" submerged-arc process in which a sleeve around the torch furnishes a powder which inerts the atmosphere in the immediate vicinity of the flame. All welding is done by hand, and every inch of welding throughout the chamber is X-ray inspected. All welds both interior and exterior, are smoothed flush by hand grinders.

The outer wall of the chamber is fabricated similarly, with the separate 4130 formed-plates welded into place. The circumferential, welded joints in the outer wall are strengthened by hat-section stiffener rings welded into tension hoops. The completed thrust chamber is then turned on a lathe to specified diameters to insure symmetry and balance.

### Turbine Pump

The heart of the Rocketdyne engine is the



Thrust chamber and turbine assembly mounted on dolly.

turbine-pump unit, in which a single-stage, steam-driven turbine actuates a turbine fuel pump and a turbine oxydizer pump; all on a common shaft, assembled into a single component. The hydrogen-peroxide is released through a silver screen, which decomposes the peroxide into steam. The steam passes through a steel harness-manifold through the nozzles, and expands through the turbine wheel. The steam continues its expansion through an aluminum-alloy cast volute, which collects it into the exhaust manifold. It passes through a heat exchanger before being exhausted, thus furnishing a heat source for the engine's pressurization system.

The liquid oxygen turbine-pump, driven on the power-turbine shaft, passes the liquid at $-297^\circ$ F into the center of the pump, and outward through the curved passages into the taurus. The taurus carries it directly into the injector plate of the engine at high pressure.

The turbine fuel-pump, aided by the pressure within the fuel tank pumps the alcohol into dual manifolds, one on either side of the combustion chamber, down to the exit manifold, and back up through the chamber formed by the double walls of the nozzle. Pumping pressure passes it upwards through these walls to the inlet end manifold, which carries it into the injector.

### Injector System

Major Rocketdyne innovation on the basic V-2 design is in the method of injecting and mixing the fuel and oxidizer. The German version used 11 individual nozzles mounted in a hemisphere combustion-chamber, giving comparatively crude mixing at best. Rocketdyne engineers developed an injector plate continuing more than 2000 drilled holes, less than 0.125 in. diam and pitched at a variety of angles. These holes are held to a tolerance of $\pm 0.001$ in., and an angular tolerance of $\pm 15$ min of arc. These accuracies are essential for the atomization of thousands of alcohol and oxygen streams impinging at the desired pint in the combustion chamber.

Ignition at the center of the injector is by electric spark, but the engine sustains combustion until its propellant supply is shut off. The

*continued on next page*

combustion chamber attains a temperature of 5,000° F which is reduced through the regenerative cooling system to only 2,000° F at the exit cone.

### Test Program

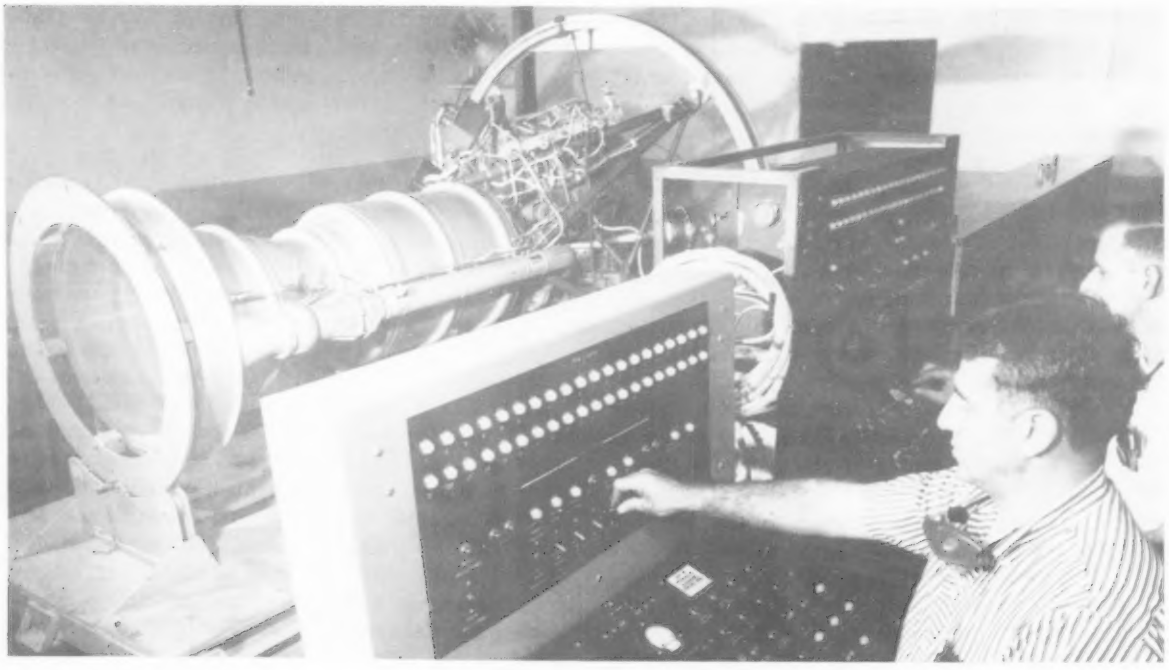
Each engine is tested statically prior to delivery. The thrust-nozzle and turbine-pump unit are assembled to a welded 4130 steel tubing; thrust mount and test instrumentation are fitted at the plant. The engine is then moved to a static-test stand. LOX and alcohol are contained in permanent "battleship" tanks atop the test stand in simulation of the Redstone missile.

The engine is given a test firing of several seconds. If adjustments or part replacement are required the engine is run a second and if further adjustments are made, a third time. The engine is then returned to the plant and disassembled. Turbine parts are closely inspected, and repairs or replacements made on any details suspected of malfunctioning during the firing test. In the event the maximum permissible test-time was exceeded during the initial firings, the engine is returned to the test facility for another firing.

After final factory approval, the complete engine is sealed in a steel container and trucked to the Army Ballistic Missile Agency, Huntsville, Ala., where it is unpacked and mounted on the Army static test-stand. After acceptance firing is complete, the engine is dried out thoroughly, sealed back in its container, and trucked to the Chrysler Missile Division plant, 30 mi. northeast of Detroit. It is then installed in the Redstone missile, and the complete missile is transported by Air Force Douglas C-124 cargo plane to the Cape Canaveral Missile Test Area.

For the special satellite launching program, the engine uses Hydne liquid fuel, a special hydrazine-based fuel developed by Rocketdyne engineers. Used interchangeably with alcohol, the new fuel requires no change in engine hardware or missile tankage. The high-energy fuel, however, provides the Jupiter-C satellite launching vehicle (A & MM, March, 1958) with a substantial increase in total burning time and burnout velocity.

Mechanics checking the pneumatic and hydraulic systems of an assembled Redstone engine.



**removable cores of stainless braid permit design flexibility and cut production costs**

# braided casting-cores

Lower cost and higher quality magnesium castings are possible with a new process that eliminates drill-jig operations in making intricate internal passages.

The process, developed by Howard Foundry Co., Chicago, uses removable metal cores covered by a stainless-steel tubular braid, especially designed and manufactured for Howard by National-Standard Co., Niles, Mich. In addition to lowering manufacturing costs, the new coring method allows designers to fit curving cores to irregular contours.

In attempting to devise improved casting methods for such complicated magnesium components as aircraft fuel control blocks, the following problems were to be considered.

Venting of gas, formed when hot metal touches an organically bonded core of sand or other refractory materials, is a difficult process in small diameter cores. Gas trapped in the cooling metal, if not allowed to escape through the core, tends to bubble through the metal, and causes blows. In instances where the ratio of core length to core diameter is large, the core must be particularly permeable to gas flow, to prevent this occurrence.

### Small Cores Are Delicate

But, even where permeability is not a factor long cores of small diameter are extremely delicate. It is difficult to manufacture a stable distortion-resistant core.

Rigid stainless-steel tubing, though used for many years as a permanent core in magnesium alloy castings, has serious drawbacks: Electrochemical damage results if the liquid flowing in the passage acts as an electrolyte. Remelting of scrapped castings is complicated because nickel and chromium in the steel may dissolve in the liquid magnesium enough to exceed specification limits. In addition, during the cooling phase it is difficult to retain rigid stainless tubing in its required position within the mold, since it is highly susceptible to displacement through blows.

The approach to the problem, devised by R. F. Dalton, manager of the company's research and development division, centered upon the use of pliable metallic tubing that could be bent to shape easily, and could be dissolved by acid after the casting was made. At first copper tubing seemed ideal because of its availability in a wide range of diameters and tempers, and its solubility in acid.

### Glass Fiber Gives Protection

However, copper also dissolves in molten aluminum and magnesium. In casting aluminum, it was discovered that a glass fiber sleeve insulated the copper from molten metal, and provided an excellent core material surface against which the molten metal would lay.

After the copper was completely dissolved, and the cavity flushed with water, the glass fiber covering was easily pulled from the casting. Visual examination of the sleeve provided positive proof of tube removal and hole cleanliness.

A further refinement was required to adapt the process to casting magnesium. A 50-50 mixture of 70 per cent nitric acid, and 70 per cent hydrofluoric acid was required to prevent etching of the magnesium alloy casting by the nitric acid seeping through the glass fiber. The nitric acid dissolved the copper, and the hydrofluoric acid passivated the magnesium.

Hydrofluoric acid, however, also partially dissolved the glass fiber sheath around the copper core tube, and the dissolved fiber tended to plug the cored hole, and to slow the flow of acid.

*continued on next page*

# braided casting-cores

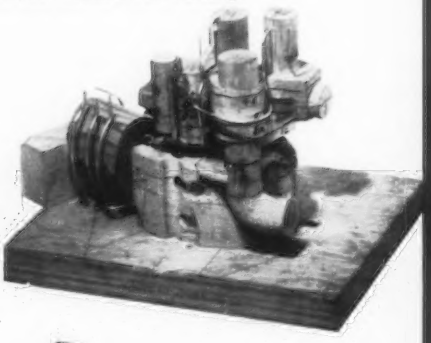
continued

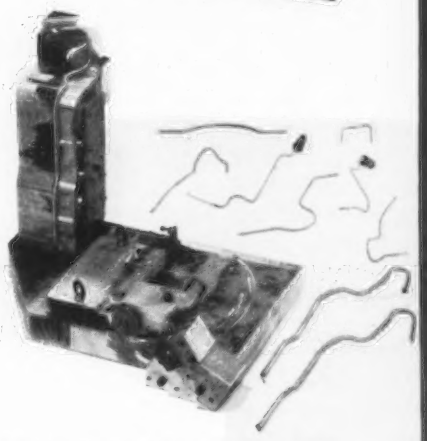
### Custom Braid Is Answer

At this stage, the merits of stainless-steel tubular braid were considered, and to this end national-Standard engineers were consulted. They pointed out that standard braids were too coarse for his application, and manufactured several special, experimental samples. Upon successful casting tests six sizes were adopted for cores $\frac{1}{8}$ to $\frac{3}{8}$ in. diameter; sand cores are practical for larger diameters.

Each of these braids is made of 0.0036-in. diameter, Type 304 stainless; small wire diameter contributes to flexibility. Five or seven wires per carrier (groups of parallel wires braided with other carriers), and 24 or 48 carriers are used, depending upon the diameter.

Pine model core-mockup of an aluminum-alloy sand casting features complex coring passages needed for venting.





¼-in. diam tube-bending fixture is shown with samples of sheated tubing. Cork-shaped objects in upper right are steel core prints used to locate holes accurately in castings.

### Offers Greater Design Freedom

The custom braid is porous enough to permit passage of any gas that might form in pouring, tight enough to block passage of molten metal, and so flexible that a $\frac{3}{8}$-in. diameter core sheath can be pulled through a $\frac{1}{8}$-in. diameter hole if desired.

Applications of this patented process are already being utilized in the production of various aircraft components. The method permits greater freedom in designing complex passages for oil, fuel, coolant and hydraulic fluids. Integrally-cast lines can be branched-off in many directions, and made to assume almost any desired shape.

Besides reducing the weight of castings using permanent, cast-in, stainless-steel tubing, integral tube coring makes it possible to provide intricately-shaped conduits for unrelated distribution of fluids, and eliminates the need for externally hung lines.

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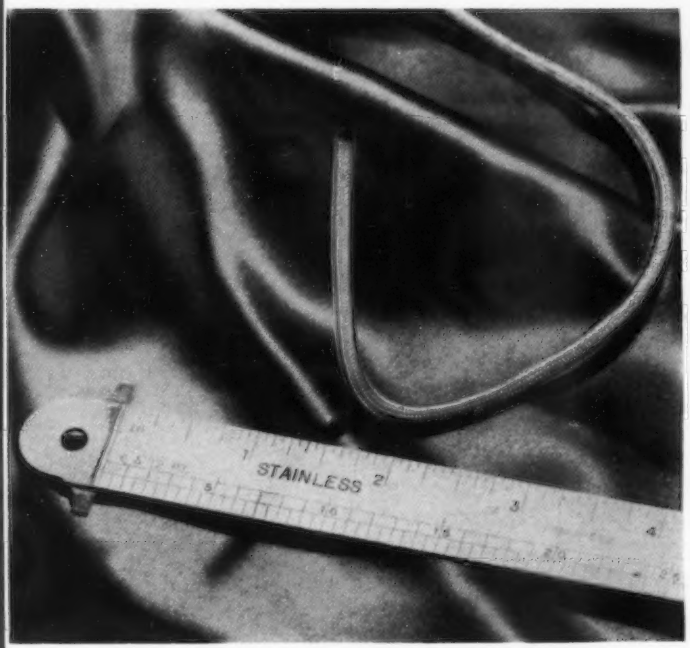
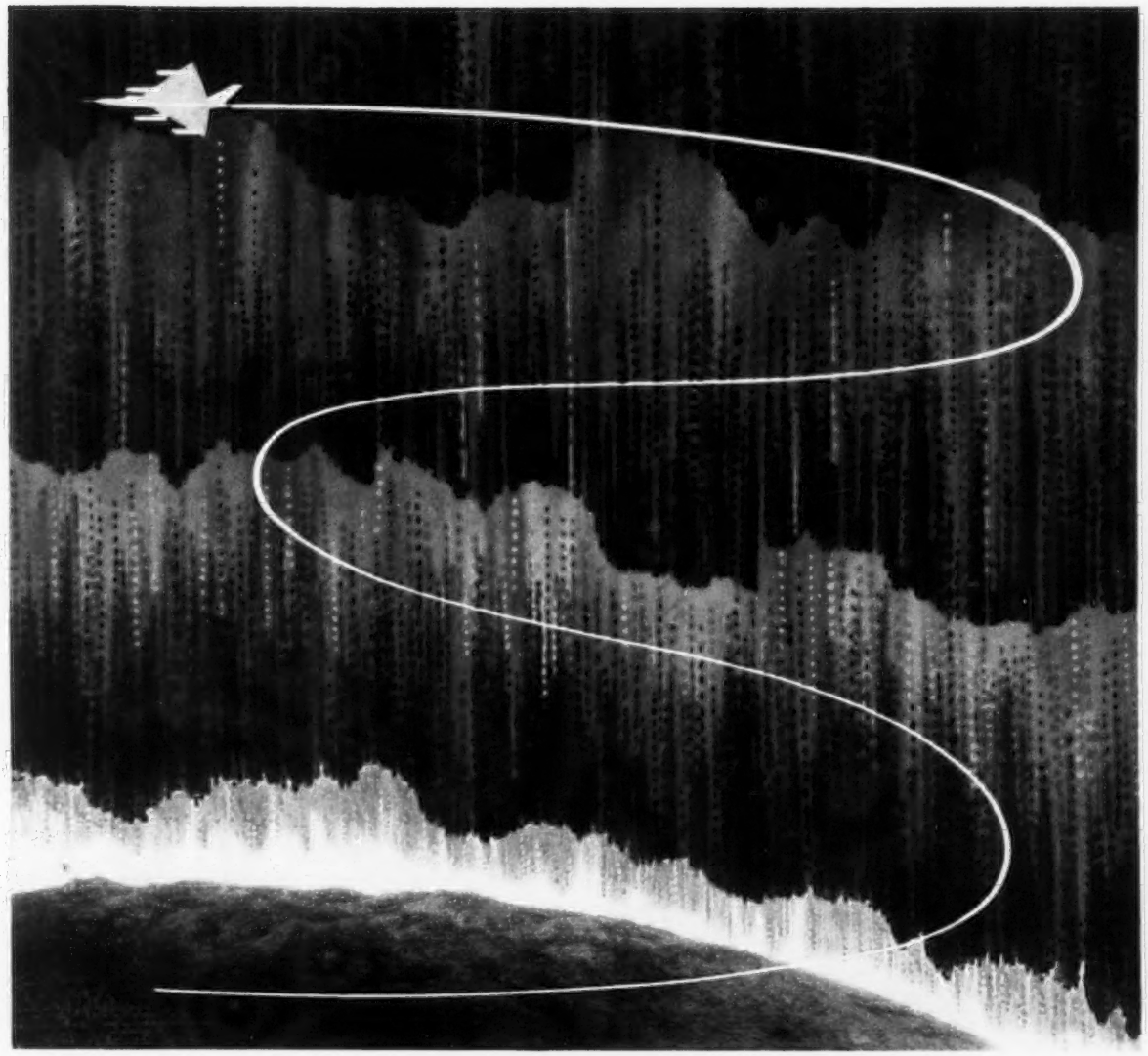



1/8-in. diam, 7 x 24 x 0.0036 type 304 stainless braid used for coring.



## New extreme-high-temperature lubricants for missiles and supersonic aircraft **SHELL ETR GREASES**

One of the serious lubricating problems faced by designers of missiles and supersonic aircraft has been solved by scientists at Shell Research Laboratories.

The problem: to find a grease which would permit components to operate with certainty under extreme high temperatures. Co-operation with representatives of bearing manufacturers and military personnel resulted in a completely new class of greases—SHELL ETR GREASES.

These greases can easily withstand temperatures up to 600°F. They give superior lubricating performance because of a special thickener—an organic vat dye—which has exceptional heat stability and jelling efficiency.

If you are presently in the market for an ultra-high-temperature-range grease, we will be glad to provide more information on Shell ETR Greases.

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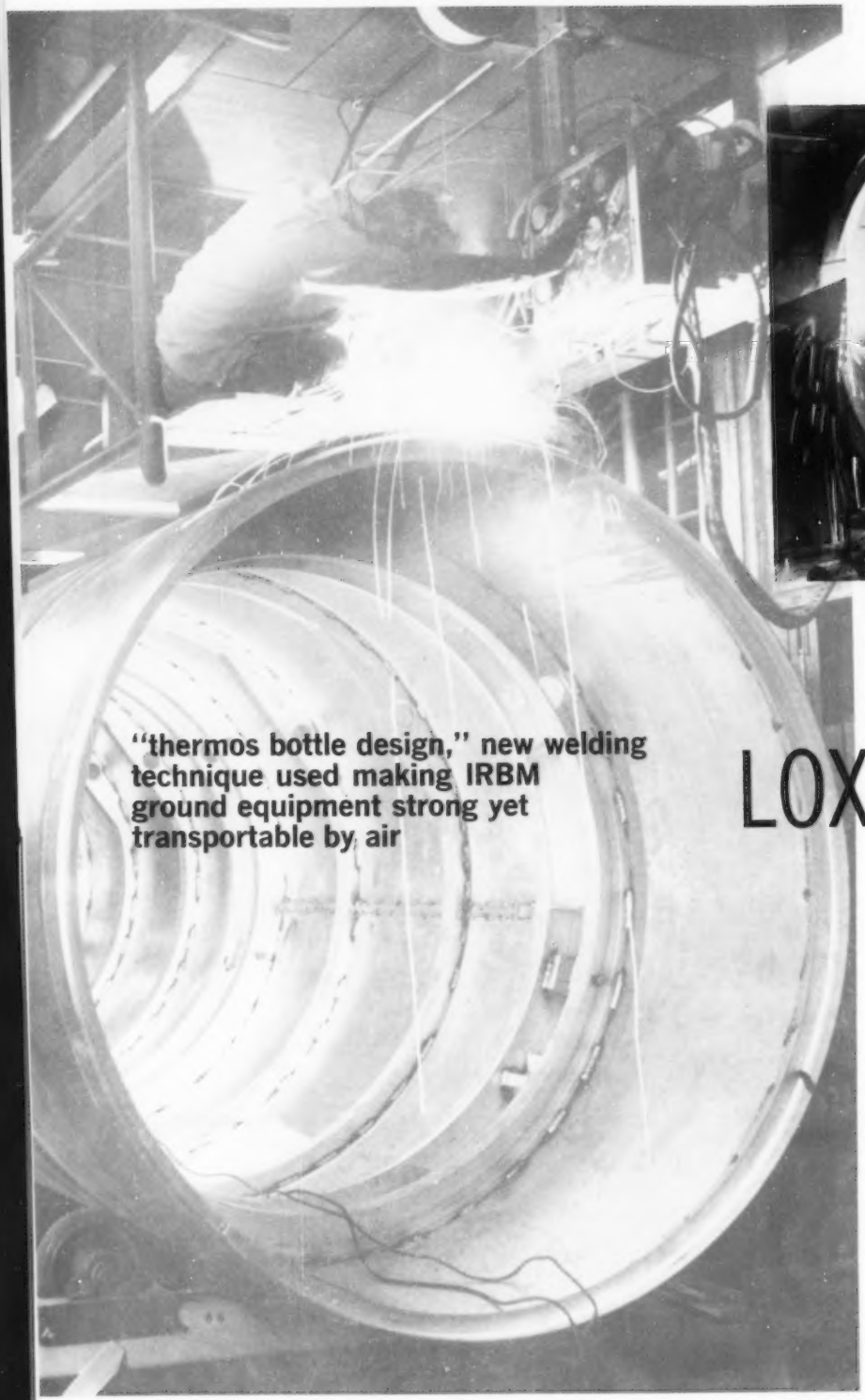
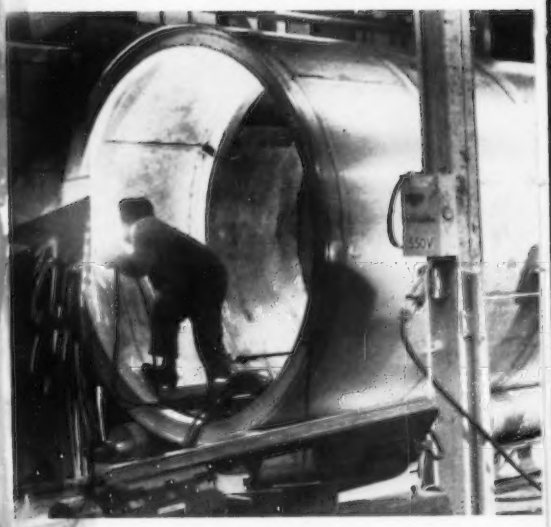
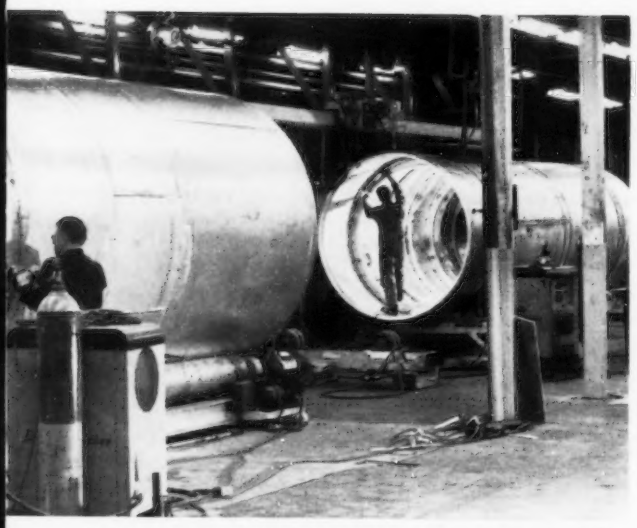




**"thermos bottle design," new welding technique used making IRBM ground equipment strong yet transportable by air**

# LOX tanks for

Outer shell of "thermos bottle" liquid oxygen transfer tanks used as ground support equipment for Thor IRBM is fabricated of aluminum.
Welding process to insure a high vacuum seal was developed by Cambridge Corp., tank manufacturer. Extruded ribs give support to O.D. welds.



Tack welds are made on the inside of the aluminum shell before automatic circumferential welding on the O.D. Tanks are manufactured on both the East and West coasts but still must be transportable by air.

# Thor

Written into the specifications for the construction of fuel storage and transfer tanks for one of the first ballistics missiles scheduled to "go operational" was a requirement which made the existence of world-wide Thor launching sites dependent on existing aircraft design. The words were—"must be transportable by air."

The liquid oxygen (LOX) storage and transfer tanks for Thor, manufactured in Lowell, Mass., and Los Angeles, Calif., are composed of an inner stainless steel liner and an outer shell of aluminum. The area between the components is evacuated, making the tank similar to a huge, thermos bottle in design.

The major design and fabrication problem was to make the huge tanks (50 ft x 8 ft) strong enough to hold 13,500 gal of LOX at —297.4°F, yet light enough to transport by air.

This was accomplished by constructing the outer liner of aluminum, thus reducing the empty weight of the tank to 32,000 lb. In fabricating the outer tank extruded aluminum ribs were shaped to form a socket for the outer shell sections. This permitted all welded seams to have 100 percent mechanical support under them. This fabrication technique has never been used in this way before. All weldments were required to remain helium leak-proof under vacuum conditions.

LOX stored in the inner tank must be maintained at 99.9 percent purity, this demanded new stainless steel cleaning techniques for the weldments.

Worker grinds weldments in applying finishing touches to outer-shell dome section.

First completed tank ready for shipment is examined by officials of organizations involved in production.

# TRENDS IN—
# high temperature metals

**high melting-point metals plagued by low ductility and poor oxidation resistance, use of cermets and other composite materials to be extended, engine metals modified for structural uses**

by **Julius J. Harwood**, chief metallurgy branch, Office of Naval Research

This is the second part of a two-part article in which the author has examined the state of development and possible applications of the new, as well as, the tried and tested metals.

Part one, which was published in May, discussed the metals usually associated with airframe construction.

In Part two, metals and composite materials used for reentry, gas-turbine, and rocket applications are examined.

The choice of materials which can satisfy reentry requirements is limited; much attention is now being given to thermal-protection systems. By this is meant the cooling of the load-carrying structure to relatively low temperatures by use of various systems which prevent the heat flux from penetrating to the primary structure. Such schemes include ablation and sublimation coatings, transpiration, film or liquid-metal cooling, heat sinks and insulating outer coatings. With the development of high strength-to-weight ratio materials, thermal-protection systems offer most attractive potentialities, particularly for severe reentry conditions. Such systems are also applicable to the difficult materials problems associated with vehicles subjected to high steady-state heating.

### Composite Materials

Thermal-protection systems emphasize the recognition that for many applications no single material could exhibit all of the desired characteristics. Therefore, composite materials and structures embodying the desirable characteristics of several materials are used to cope with operational environments. The current use of reinforced plastics, honeycomb and sandwich construction typify this approach.

Various approaches, ranging from pure metals containing finely-dispersed oxide particles, to ceramics containing metal fibers, are being investigated for the development of composite materials with superior high-temperature properties.

A promising composite material under development is one of aluminum-coated glass fibers in an aluminum alloy matrix. The glass content varies from 20 to 60 per cent, depending upon properties desired. Although the room-temperature tensile strength of this material is still low, it has very nearly-constant temperature strength up to 900°F. Its ductility however is still quite low.

### Materials for Use Above 1500° F

Until recently the need for materials with strength capabilities above 1500°F arose primarily from the requirements of gas turbines, ram-jets and rocket motors. However, anticipated skin-temperature greater than 1000°F, the development of nuclear powerplants, and the sheet requirements for ballistic missiles and other advanced weapons systems make it likely that materials normally associated with gas turbine developments will receive consideration also for these new airframe applications.

In the past, much of the effort directed to the development of high-temperature materials was intended for the turbine stage of jet engines; the military benefits to be achieved from increasing turbine operating temperatures to 2000°F were highly significant.

Unlike most missile applications, long-time high-temperature properties (hundreds of hours) are a major criterion in aircraft gas turbines. The creep-strength, fatigue-strength, thermal-shock and oxidation requirements for turbine-blade materials make this a difficult type of application.

Operating temperatures of current aircraft gas-turbines may run up to about 1650°F. The

chemical compositions of representative turbine-blade materials are shown in Table 8. They fall, generally, into three groupings; cobalt-base alloys, nickel-base alloys, and nickel-chrome-cobalt alloys.

Improvements in nickel-base alloys have permitted an increase in turbine-inlet temperature to 1650°F with strong possibilities of going to 1700 to 1750°F. These nickel-base alloys derive their high-temperature strength properties from the age-hardening reactions involving aluminum and titanium. The use of vacuum-melting techniques has enabled in large part the development of these superior nickel-base alloys. Vacuum melting is said to result in: better forgeability and greater recovery of sound material; superior fatigue-limit-to-tensile-strength ratio; greater ductility; greater high-temperature strength properties; greater resistance to intergranular penetration; and better overall combination of properties.

Typical example of nickel-base alloys include Inco 700, Waspalloy, M252, and GMR 235.

Similar developments in cobalt-base alloys are in progress. However, it appears that the temperature limitations for highly-stressed, long-service applications of these super alloys are being rapidly approached. Some typical creep-rupture properties of representative alloys are shown in Fig. 10.

Nickel-base alloys have been used in sheet form for afterburner combustion-chambers, in ram-jet engines, and in related components exposed to combustion gases. Thus technical know-how concerning sheet fabrication and forming, and sheet-metal structures of these alloys is available. While progress has been made, it is quite obvious that new alloy systems will need to be employed for operating temperatures above 2000°F.

### Refractory Metals

One group of metals which has attracted considerable attention for high-temperature applications in gas turbines, ram-jets and missiles is the refractory family—so called because of the high melting points typical of the group. These metals and their properties were listed in Table 5. Zirconium, hafnium and columbium, because of their nuclear properties, are finding usage in nuclear power-plants.

The development of molybdenum base alloys with outstanding strength-properties at temperatures above 1800°F has been one of the most significant alloy achievements of the past decade. The commercial availability of such high-temperature, high-strength alloys provides potentially promising materials to partially-fill the needs of advanced gas turbines, ram-jets, rockets, and long-range missiles. In the temperature range of 1600 to 2000°F pure molybdenum exhibits better rupture-strength than the best nickel, cobalt or other super-alloys. At 2000°F molybdenum-base alloys have strength properties superior to commercial gas-turbine blade material tested at 1600°F.

Mo-0.50 per cent Ti alloy is in commercial production and Mo-0.44 Ti-0.07 Zr alloy is rapidly approaching that stage. Despite its high density, the strength-to-weight ratio of molybdenum alloys surpasses that of all commercial alloys above 1500°F. Molybdenum retains useful strength-properties almost up to its melting point, and exhibits a low-temperature dependence of its modulus of elasticity ($45 \times 10^6$ psi at room temperature).

Unfortunately, a major obstacle limits the widespread use of molybdenum alloys for turbine and other long-time high-temperature applications. Molybdenum and its alloys undergo rapid oxidation; hence, satisfactory protective coatings are required. Much effort has proceeded along these lines and sprayed coatings, cladding and electroplated nickel-chromium coatings appear promising for use up to 2000°F. The rewards from the solution of the problem of the protection

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Fig. 10. Strengths to be expected of several high-temperature metal categories are plotted against temperature.

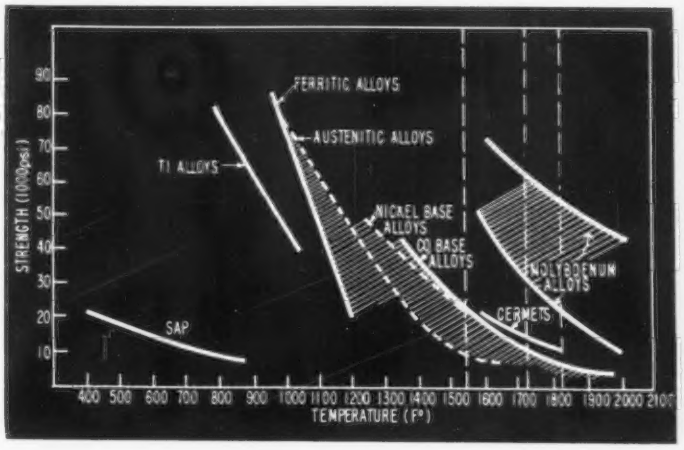


**Table V. Refractory Metals.**

| Refractory Metals | Melting Point (° F) | Density (g/cc) | Modulus of Elasticity (psi) |
|---|---|---|---|
| Tungsten | 6170 | 19.3 | $50 \times 10^6$ |
| Rhenium | 5740 | 20.0 | $42 \times 10^6$ |
| Tantalum | 5425 | 16.6 | $27 \times 10^6$ |
| Osmium | 4900 | 22.5 | $80 \times 10^6$ |
| Molybdenum | 4760 | 10.2 | $45 \times 10^6$ |
| Iridium | 4450 | 22.5 | $75 \times 10^6$ |
| Columbium | 4380 | 8.57 | $13 \times 10^6$ |
| Chromium | 3430 | 7.19 | $36 \times 10^6$ |
| Zirconium | 3380 | 6.5 | $14 \times 10^6$ |
| Titanium | 3140 | 4.5 | $15 \times 10^6$ |
| Vanadium | 3125 | 6.11 | $21\text{-}22.5 \times 10^6$ |
| Hafnium | 3100 | 11.4 | $20 \times 10^6$ |

**Table IX. The Effect of Temperature on Strength Properties of Cb**

| Temp°F | Proportional Limit, 1000 psi | Tensile Strength, 1000 psi | Elongation, percent | Modulus of Elasticity, $10^6$ psi |
|---|---|---|---|---|
| 68 | 24.2 | 39.4 | 49 | 12.4 |
| 392 | 14.6 | 33.6 | 48 | 10.9 |
| 572 | 14.1 | 34.7 | 38 | 8.0 |
| 752 | 14.6 | 33.2 | 28 | 7.5 |
| 932 | 15.2 | 35.6 | 35 | 6.4 |
| 1022 | 10.5 | 32.3 | 24 | 4.7 |

Fig. 9. Alloyed, or unalloyed molybdenum generally exhibits better high-temperature strength properties than the "super strength" alloys.

**Table XII. Results of Tests on Sprayed-Metal Coatings for Molybdenum**

| Type of Test | Al-Cr-Si | Ni-Cr-B | Ni-Si-B |
|---|---|---|---|
| (a) Oxidation Test at 1800°F* followed by (b) Oxidation Test at 2000°F | 500+hr. 100+ | 500+hr. 100+ | 500+hr. 100+ |
| (a) Oxidation Tests at 1800°F of Cylinders with 5 mils Coating thickness followed by (b) Oxidation Test at 2000°F | 500+hr. 283-500+ | 500+hr. 83-500+ | |
| Thermal Shock Tests (3 Specimens) number of cycles to failure | 504-627 | 185-285 | 108-150 |
| Ballistic Impact Test on 3 Specimens (velocity of shot 330 ft/sec) life of coating at 1800°F after impacting | 0** | 500+hr. | 500+hr. |
| Erosion Test on 2 Specimens, using 30 to 33g. per min. No. 90 aluminum oxide grit; life of coating at 1800°F | 25-30 min. | 57-60 min. | 40-50 min. |

*—75 consecutive specimens with Al-Cr-Si coating sustained 500 hours exposure without failure at 1800°F.

** With a shot velocity of 135 ft/sec, specimen life after impacting was 160-170 hr.

**continued**

of molybdenum alloys would be a potential increase in gas-turbine operating temperatures of over 400°F.

Despite this poor resistance to oxidizing environments, molybdenum alloys are finding increasing usage in ram-jet, rocket and missile components, particularly in sheet form. Molybdenum alloys are being used in one of the most vital components of the Navy's Fleet Ballistic Missile. These alloys hold great promise for use at temperatures even as high as 3000°F. Improved weldability and fabricability, and an increased ductility would ensure the role of molybdenum as a super-high-temperature material.

Recent announcements of increased availability of columbium (niobium) ores have led to increased attention to columbium alloys as high-temperature structural materials. Similar to molybdenum, columbium exhibits outstanding strength properties at 1800°F, e.g. 100-hour stress to rupture strength of 15,000 psi. Although at the moment, niobium alloys do not exhibit the outstanding strength potential of molybdenum alloys, it appears that they will be useful structural materials up to about 2200°F.

While columbium also has poor oxidation-resistance, unlike molybdenum it does not have a volatile oxide, and does not suffer catastrophic failures. Improved oxidation-resistant alloys of columbium are now appearing, and coating techniques can be resorted to, if necessary. Like the other high-melting metals, columbium is sensitive to contamination by oxygen and nitrogen, but in general is much easier to fabricate than most other refractory metals.

Chromium-base alloys also have been developed which exhibit good high-temperature properties up to 1800°F. Experimental alloys containing 45 to 50 per cent Ni have strength properties at this temperature better than the current nickel and cobalt-base alloys. Chromium-base alloys suffer from the same disadvantage as most other high-strength materials, namely low ductility. However, recent work on the preparation of ductile chromium and more ductile chromium-base alloys, offers encouragement for the future availability of a series of alloys useful up to 2000°F.

Since there are an increasing number of applications in which materials must withstand combustion temperatures above 5000°F, exploration of tungsten and tantalum alloys is also underway. This work is still in a preliminary state. Alloys of rhenium, osmium, iridium and ruthenium are also under investigation. Despite the limited

availability of these metals and their high densities, they may find a useful role for special applications.

### Cermets

The most highly developed cermets are the cemented titanium-carbide grades containing nickel-base alloys as the binder material. A sizeable amount of work also has been accomplished with chromium-boride cermets using chromium-molybdenum alloys as binders, and the chromium-molybdenum-alumina cermets.

While these cermets exhibit useful and, in some instances, truly impressive strength properties from 1800 to 2000°F, their lack of ductility, high notch-sensitivity, low impact-resistance, and erratic thermal-shock resistance have been discouraging obstacles to their utilization in aircraft gas-turbines. The stress-to-rupture properties of some carbide and bromide cermets are shown in Tables 10 and 11.

Cermets should be promising materials for small gas-turbine applications. Integral disc and blade titanium-carbide turbine wheels have been successfully spin-tested. Tests are now underway to explore the potentialities of cermets for small-turbine applications in which high-heat input, high-temperature (2500°F) operation is required.

Cermets have had wide application as rocket-motor exit nozzles. Silicon-nitride bonded, silicon-carbide has been extensively used and other ceramic-metal compositions, such as zirconium boride, show promise for high-temperature operation up to 5000°F.

### Graphite

Not to be overlooked in the category of structural materials is graphite. Its low density, outstanding thermal-shock resistance and high sublimation-temperature (7000°F) have made it an important material in missiles, ram-jet and rocket application; e.g. guide vanes, nozzles, etc. Above 4500°F, graphite has superior strength properties to molybdenum and other refractory metals, which begin to deteriorate badly as their melting points are approached.

The low oxidation and erosion-resistance of graphite still remain as major problems but some improvements along these lines have been accomplished by converting the surface to carbides of silicone, molybdenum, titanium, and boron.

### Vanadium Alloys

Ductile vanadium has been developed in recent years (Table 7) and vanadium alloys are receiving preliminary consideration for moderate-temperature application. Single-phase vanadium-titanium alloys (5 to 20 per cent Ti) have been developed which exhibit room-temperature strengths from 80,000 to 100,000 psi, good high-temperature strength retention, excellent formability, and good weldability (Fig. 8). The ductility, weldability, and high-temperature properties, within the range of 800 to 1100°F, and strength-to-weight features of the vanadium-titanium alloys appear to be superior to that of commercial titanium alloys. Above 1150°F its oxidation-resistance is poor, therefore protective coatings are required. Vanadium alloys are of interest also as fuel-element canning materials for fast reactors.

### Future Expectations

The materials problems and limitations, which now confront us are not absolute blocks to

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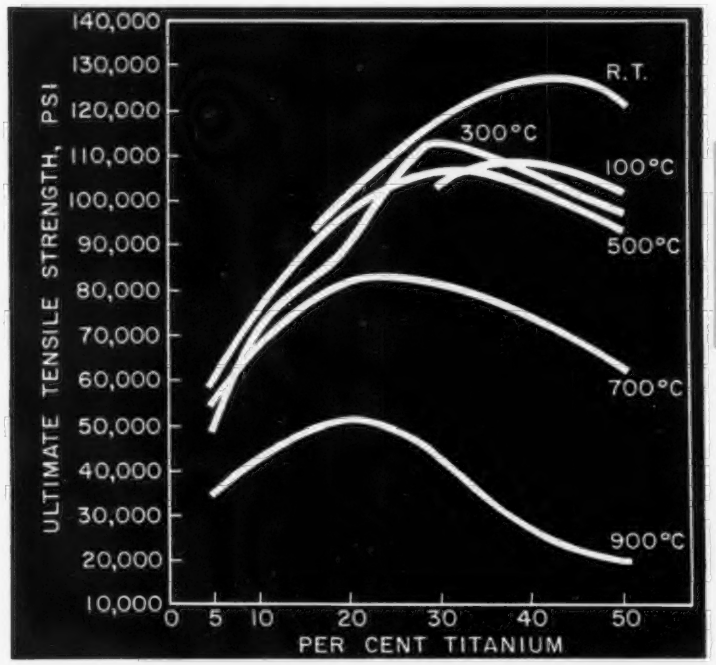



Table X. Chromium Boride Cermet Stress-Rupture Properties

| Temperature (°F) | 10 hour | 100 hour | 1000 hour |
|---|---|---|---|
| 1600 | 150,000 psi | 71,000 psi | 36,000 psi |
| 1800 | 78,000 psi | 41,000 psi | 21,500 psi |
| 2000 | 24,000 psi | 16,000 psi | 11,000 psi |
| 2100 | 13,200 psi | 9300 psi | 6500 psi |

**Fig. 8. Vanadium alloys are receiving preliminary consideration for moderate temperature applications. Vanadium-titanium alloys have good formability and weldability.**

the feasibility of space travel. Proper design and engineering considerations have overcome many such limitations, although compromises were, of course, inevitable.

The trend toward higher speeds and sustained flight at such speeds, the introduction of new fuels whose combustion temperatures exceed the melting point of most materials, and the requirements of nuclear power-plants for rocket and missile propulsion make it imperative that improvements in materials continuously be sought. It can be anticipated that cooling systems and thermal-protection systems involving a combination of insulation and cooling will play a major role in coping with the difficult problems.

From a purely materials standpoint, research now underway offers exciting and intriguing possibilities for major improvements, and in the introduction of new types of structural materials. Fine-particle strengthening of metals, new composite-materials, ductile ceramics, prestressed ceramics, and the exploitation of the tremendous strengths of metal whiskers are all encouraging possibilities. There will be a much closer relationship between design and materials, and new design and application principles will be developed to take maximum advantage of advances in materials technology.

However, the role of new and exotic materials should not be exaggerated. They are urgently needed for vital, high-temperature problem areas, but there will always be applications in advanced aerial vehicles for conventional structural alloys and refractories.

Table VII. Mechanical Properties of Vanadium.

| Treatment | Tensile Strength (psi) | Yield Strength (psi) | Elongation (%) | Red. in Area (%) |
|---|---|---|---|---|
| Annealed | 55,000-75,000 | 42,000-65,000 | 26-38 | 66-82 |
| Cold Rolled | | | | |
| " 60% | 107,000 | 101,000 | 2-5 | — |
| " 75% | 117,000 | 110,000 | 2-5 | — |
| " 80% | 155,000 | 142,000 | 2-5 | — |

Table VIII. Chemical Compositions of Representative High-Temperature Alloys

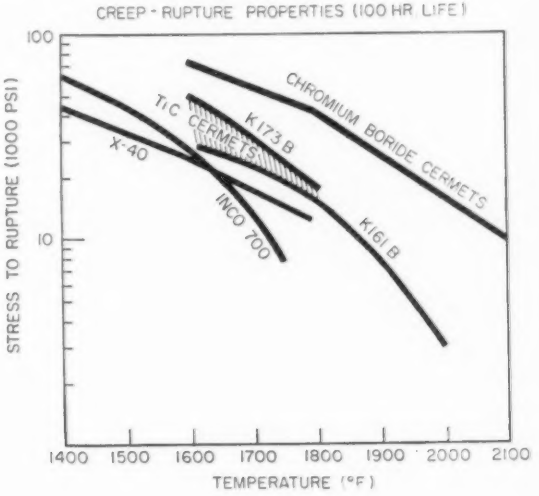
| Alloy | Cr | Co | Ni | W | Co | Mo | Fe | Ti | Al |
|---|---|---|---|---|---|---|---|---|---|
| Cobalt Base | | | | | | | | | |
| Vitallium | 27 | 64 | 2 | | | 5 | 2 | | |
| X40 | 25 | 55 | 10.3 | 7.4 | | | 1 | | |
| S816 | 20 | 43.7 | 20 | 4 | 3.75 | 4 | 2.8 | | |
| Ni-Cr-Co Base | | | | | | | | | |
| N155 | 21 | 20 | 20 | 2 | 1 | 3 | 30 | | |
| Refractalloy 26 | 18 | 20 | 37 | | | 3 | 18 | 2.8 | 0.2 |
| Nickel Base | | | | | | | | | |
| Inconel X | 15 | | 72.5 | | 1 | | 7 | 2.5 | .7 |
| Nimonic 90 | 19.5 | 19.5 | 55.5 | | | | 0.5 | 2.5 | 1.2 |

Table XI. Comparison of Stress to Rupture Properties for 100 Hour Life

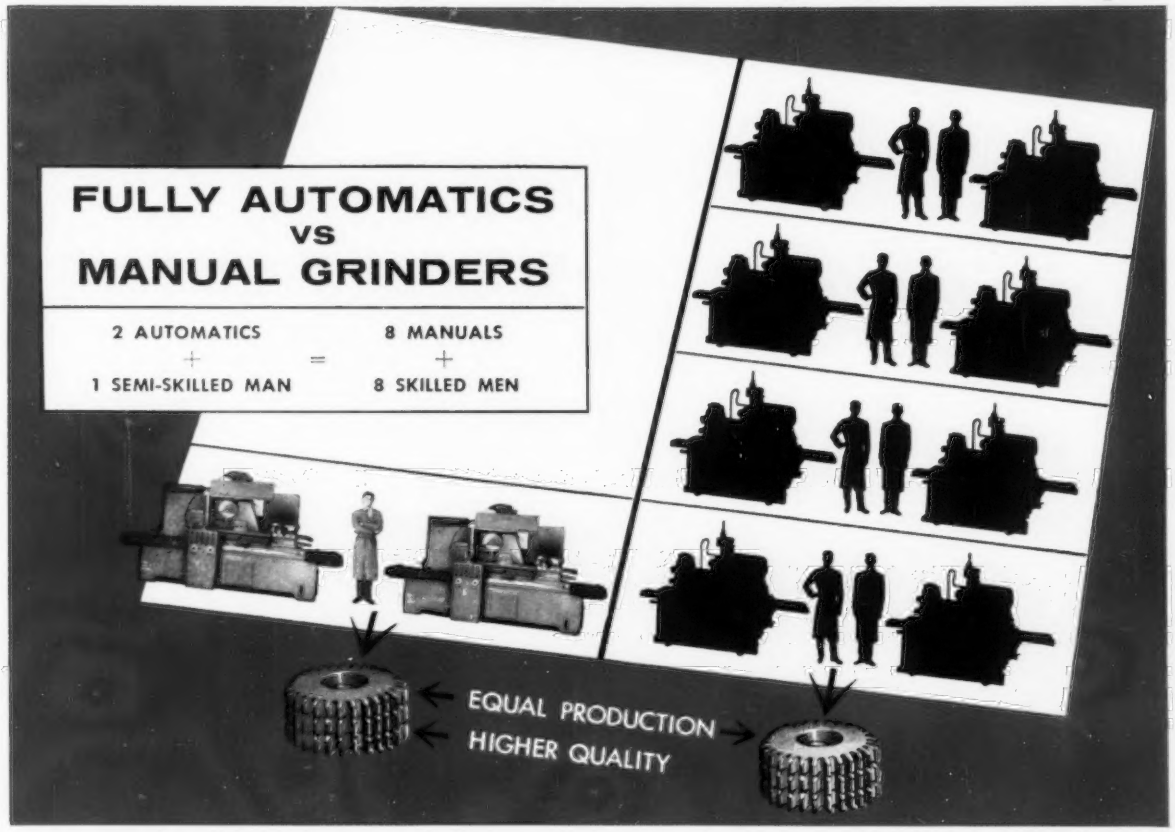
| | 1600°F | | 1800°F | | 2000°F | |
|---|---|---|---|---|---|---|
| | S* | S/D** | S | S/D | S | S/D |
| TiC Cermets | 30,000<br>44,500 | 4700<br>7200 | 15,000<br>17,500 | 2400<br>2900 | 3000 | 475 |
| Boride Cermets | 71,000 | 9750 | 41,000 | 5600 | 16,000 | 2100 |
| Mo Base Alloys (SR) (a) | 70,000 | 6850 | 60,000 | 5800 | 40,000 | 3920 |
| Mo Base Alloys (R) (b) | 35,000 | 3420 | 28,000 | 2740 | 21,000 | 2060 |

*S = Stress to rupture
**S/D = Rupture stress/density ratio
(a) = Stress-relieved condition
(b) = Recrystallized condition

Fig. 11. The high creep-rupture properties of the chromium-boride cermets are evident at elevated temperatures.



# Precision gear grinding economy

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3 Rough grind; semi-finish grind; finish grind
4 Manual grind

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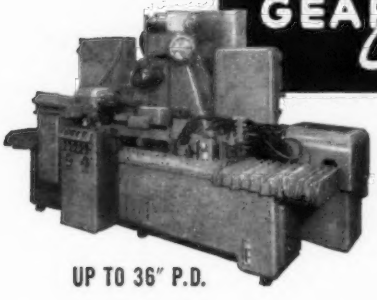

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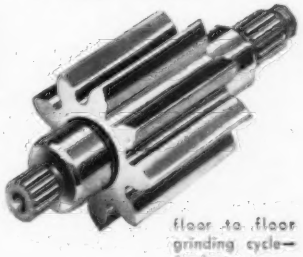

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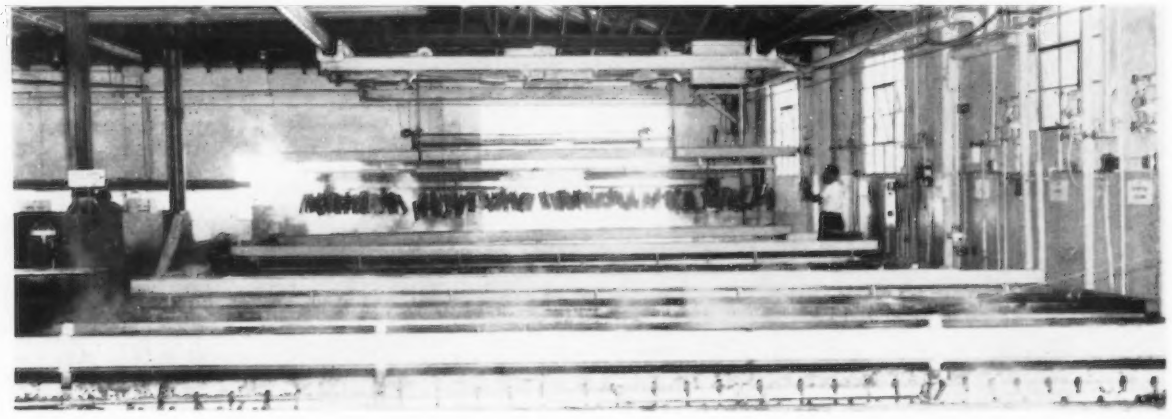
Circle 39 on Inquiry Card, page 65

# "hard anodizing" magnesium

## electrolytic and bifluoride-dichromate treatment gives increased corrosion and abrasion resistance

by Edward Delamater
chief quality control engineer, Anadite, Inc.

Precision surface treatments are speeded by this array of tanks fed by overhead traveling crane at Anadite, Inc. Process requires different sequence and times of rack insertions in various baths to "hard anodize."



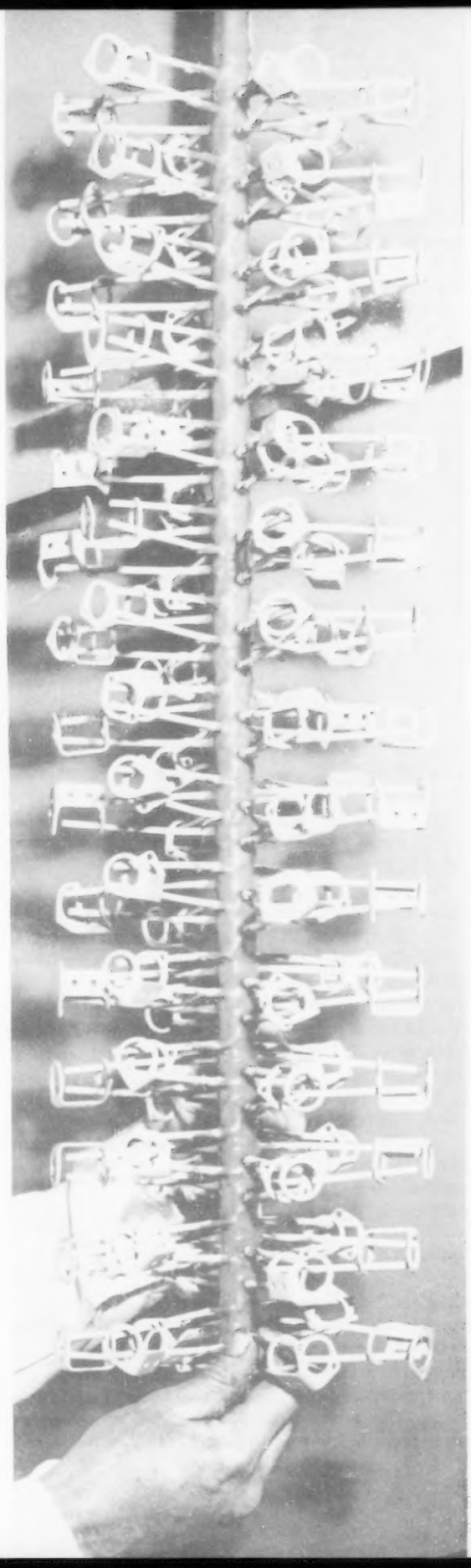
Despite its excellent strength-to-weight ratio, magnesium and its alloys have never realized their full potential for aircraft and missile applications. One of the prime reasons for this is the metal's sensitivity to corrosion, and unwillingness to respond to conventional treatment for anodic film protection.

Various chemically deposited and paint-like coatings have been used to protect the metal, but none has provided the combination of corrosion and abrasion resistance airframe manufacturers consider optimum.

Finding new application for production parts, is a "hard anodizing" process which creates a tenacious film of magnesium aluminate, and other materials of the spinel class, that exhibit a hardness of 7 to 8 on the Moh scale and an ability abrade steel of Rockwell C-65 hardness. This wear resistant surface may be used alone, with assurance of excellent corrosion resistance, or (contrary to conventional thinking that alkaline baths are inferior as a base for paint and other organic finishes) may be used as a primer layer to accept mechanically deposited organic films.

The "hard anodizing" process differs from ordinary anodic deposits in that it employs alternating current rather than direct; the bath tank does not serve as the cathode; and most important, the ultimate protective film is not an oxide deposit but rather is a mixture of spinels, (largely magnesium aluminate), resulting from a true reaction of the bath solution and the magnesium parts.

Corrosion resistance is enhanced considerably by the post-treatment which consists of dipping the parts, with the initial electro-deposit of magnesium oxide and spinels in a bifluoride-dichromate bath and drying in a controlled high humidity atmosphere without rinsing. This step is referred to as aging and requires about two hours. Any oxide is converted to a spinel material in the past treatment. Where time permits, a



Quality control inspector checks accuracy of rack spacing to insure against burring or arcing between parts during anodizing treatment. When air pockets develop, parts must be revolved to clear bubble and bring solution into complete envelopment of part.

second bifluoride-dichromate dip and aging will further increase corrosion resistance.

Natural aging continues to increase corrosion resistance on in-service-parts. Test panels exposed in a salt spray cabinet six months after post treatment showed almost 100 per cent improvement over those exposed the day following post treatment.

### Part Preparation

Before the "hard anodizing" treatment begins, parts are inspected for damage caused in transit, and for machining marks severe enough to demand rejection.

TABLE II

Salt Spray Tests

Comparison of "hard anodize" and other anodic treatments

| Treatment | 24 hour exposure |
|---|---|
| A | 15 pits/sq in. av |
| B | 35 percent corroded |
| C | 2 pits/sq in. av |
| D | no corrosion |

Treatment A represents a proprietary coating produced in an alkalin bath consisting of caustic soda, water glass, and crystalline phenol, at temperature 175° F and current density 20 amperes per square foot. Treatment time 30 minutes.

Treatment B represents the acid dichromate chemical process. This consists of 5-minute immersion in hydrofluoric acid solution and 30 minutes' treatment in a dichromate bath at temperatures near boiling.

Treatment C represents a new anodic-type proprietary coating produced in an acid chromate bath, consisting of ammonium bifluoride, sodium chromate and phosphoric acid, at temperature 175° F and current density 20 amperes, alternating current, per square foot, at voltages up to 92 volts. Treatment time 15 minutes.

Treatment D represents the complete "hard anodizing" E treatment (post treatment and overnight aging).

Cleaning and surface preparation are essential to proper anodizing, but are not as critical as the demands of some other chemically and mechanically deposited films. Parts are first vapor degreased in a stabilized trichlorethylene vapor bath at 180°F, soaked for 15 to 20 min in an alkaline cleaner at 180°F, then rinsed in clean running water.

Stubborn oxide films or corrosion products may be removed by chromic acid solution. Recommended practice sheet for "hard anodizing" (HAE process for magnesium) states that acid pickles other than chromic should be avoided. However, major metal finishing firms like Anadite, Inc., Calif. have used hydrofluoric, phosphoric, and nitric, as well as chromic acid pickles on various parts. Close-tolerance machined parts are never subjected to a pickling bath strong

*continued on next page*

enough to remove metal, but in instances where tolerance observance is not too critical, stronger pickling baths are used advantageously as time savers. After pickling, the parts are again rinsed in running water and allowed to dry, prior to masking.

The individual features of a part have a strong influence in how the part is masked. Mating areas are protected by a mask so that the ensuing anodic deposit does not throw the part out of tolerance. Drilled or threaded holes are protected by inserting plastic plugs. Machined faces and other close-tolerance areas are protected by maskants. A heavy Plastisol coating has been very satisfactory as a maskant.

### Immersion in Electrolyte

The parts are then placed on racks for immersion in the anodizing bath. Parts must be accurately positioned to prevent undesirable arcing, or contact with the tank. Electrical contact with the work and copper bus bars must be through firm magnesium clips. Since magnesium is attacked at solution level, the magnesium leads should be protected at solution level. Various vinyl tapes and maskants are suitable.

Parts of complex geometric configuration must be racked and suspended in the bath in such a manner as to preclude the formation of gas pockets during anodizing.

Having considered the entire surface area of all the work pieces and leads to compute the current requirements, the parts are lowered into the anodizing bath. Current densities required are, 12 to 15 amp/sq ft at 75 to 100 v. Starting from zero, the voltage is quickly raised to 40 v then adjusted to the required level. As the coating is formed, the electrical resistance increases and voltage adjustments must be made.

The protective layer is usually built up to about 0.001 to 0.0013 in. per face. Since alternating current is used, the reaction occurs at both poles.

### Deposits of Even Thickness

The non-conductive nature of the "hard anodized" layer inherently has a tendency to build an even deposit. The current flows more readily to the bare metal, or that area of the metal which may have a lesser deposit than another area, (ie) the current follows the course of least resistance.

The process can be operated at temperatures from below zero to over 38°C. The preferred range being 25 to 35°C. During the anodizing process, electrical energy is converted to heat. When tanks are operated at maximum capacity for long periods, cooling the bath may be necessary.

After the electrolytic treatment, the parts are again rinsed in running water and given a post-treatment which enhances corrosion resistance.

### Post-treatment

Post-treatment has many variations depending on the ultimate disposition of the part. Best surfaces are attained by immersing parts for 45 sec in a solution consisting of 20 gms sodium bichromate and 100 gms ammonium bifluoride per liter of solution. The parts are not rinsed upon removal, but are allowed to age in a humid atmosphere. Humidity is excessive when it causes condensation of water vapor on the parts. Aging time may vary from 45 min to several hours, depending on corrosion resistance required and economical time allowances. The exact chemistry of the bichromate-bifluoride dip action has not been investigated, but its results are unequivocal.

### Inspection

Following post-treatment, parts are inspected for color; this has been determined as an accurate index to the quality of the "hard anodize." The coating produced is brown in color. The gradations of brown are matched against a control color panel. This has also proven a satisfactory inexpensive method for determining the strength of the bath. Detailed chemical analysis is not essential.

*Continued on page 52*

TABLE I

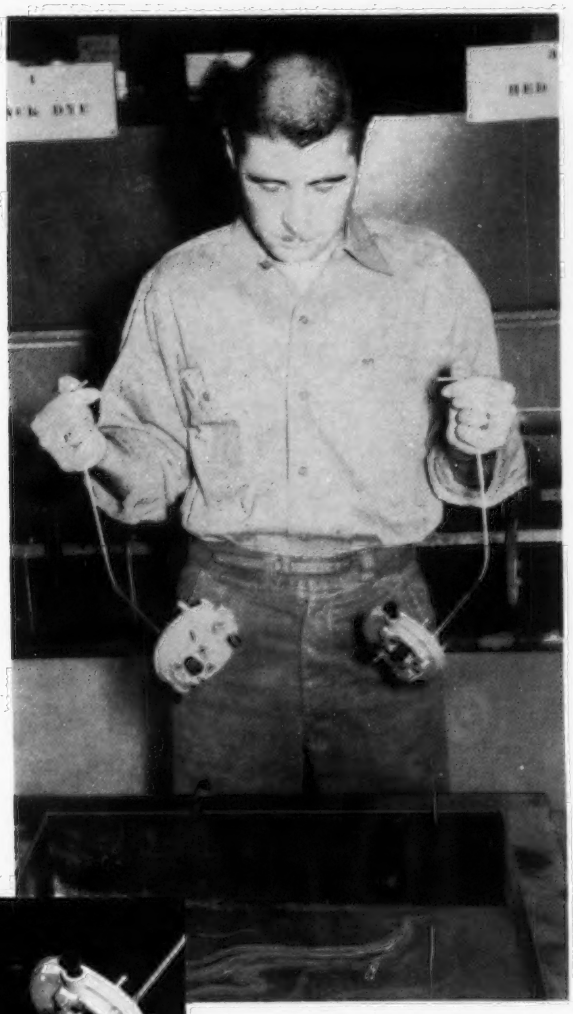
Solution Composition

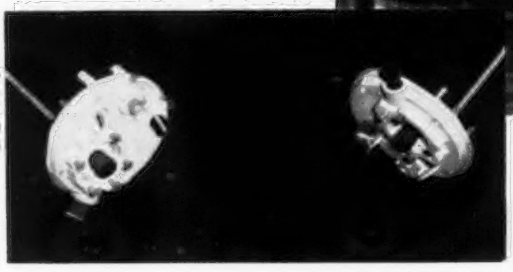
Electrolyte

| | oz/gal of solution |
|---|---|
| potassium hydroxide | 22.0 |
| aluminum hydroxide | 4.0 |
| potassium fluoride (anhydrous) | 4.5 |
| trisodium phosphate | 4.5 |
| potassium permanganate | 2.5 |

Post Treatment

| | gm/liter of solution |
|---|---|
| sodium bichromate | 20 |
| ammonium bifluoride | 100 |





Missile bulkhead assemblies receive hard anodizing surface. Note drilled passages plugged to prevent action of solution on inside bores.

TABLE III. COMPARISON OF CORROSION RESISTANCE AND LENGTH OF AGING

| Panel No. | Aging Treatment | 44-Hour Exposure | 60-Hour Exposure | 132-Hour Exposure | 180-Hour Exposure |
|---|---|---|---|---|---|
| 1 | 45 min. | No pits | No pits | No pits | No pits |
| 3 | 45 min. | No pits | No pits | 2 pits | 2 pits |
| 5 | 45 min. | No pits | No pits | No pits | No pits |
| 11 | No aging | 1 pit | 2 pits | 2 pits | 2 pits |
| 13 | No aging | 3 pits | 3 pits | 3 pits | 3 pits |
| 15 | No aging | 6 pits | 6 pits | 6 pits | 6 pits |

The results clearly show that aging greatly improves the corrosion resistance of the coating; hence it should be applied wherever maximum corrosion resistance is an essential requirement. Aging may vary from 45 minutes to 7 hours or more, depending on the degree of corrosion resistance required. Test specimens should never be exposed to salt fog the same day they have been treated.

# "hard anodizing" magnesium

**continued**

These missile parts have received hard anodizing surface treatment to increase wear-resistance. Racking of such production-quantity parts must be arranged carefully to prevent arcing destruction.

**Magnesium casting for Bomarc ramjet engine has been given HAE hard anodizing coating of 0.001 in. Masking of machined areas to prevent anodizing is precise operation but this complex part has been hard anodized without difficulty.**

## Limitations

There are certain very definite limitations to this "hard anodizing" process in spite of the outstanding results achieved with particular parts.

Parts of bimetallic composition cannot be treated without precise masking to prevent galvanic corrosion.

There is a definite loss in fatigue strength in all parts treated by this process. The loss in fatigue increases in proportion with the length of "hard anodize" treatment. Thus, there is an increasing penalty in loss of strength with each corresponding increase in corrosion resistance. This is most noticeable in thin gage material. In thicknesses over 0.9 in., the loss in fatigue strength is not too critical.

Losses in fatigue strength range from 2 per cent to 10 per cent, after 10 min treatment of 0.094 and 0.040 in. stock; from 2 per cent to 20 per cent, after 1 hour treatment of the same gage stock.

The use of "hard anodizing" on primary structures has not been advisable, but it is only fair to point out that magnesium is not used extensively as a primary structural material.

Development and employment of this process for protecting magnesium parts has already expanded its use in such functional parts as control system pulleys, quadrants, brackets and housings, and such external skins as flaps, control surfaces, and ram-jet engine housings. "Hard anodizing" produces the hardest protective surface for magnesium developed to date and is rapidly opening a variety of new applications for this metal in aircraft and missile manufacturing.

The process described is officially known as the HAE Process for Magnesium. It was developed by Mr. H. A. Evangelides, research chemist at Frankford Arsenal, Army Ordnance Department.

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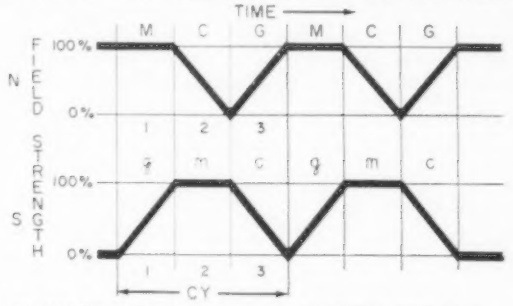
This department is created to encourage thinking in new dimensions; thinking that is free of the often constraining influence of immediate difficulties. Technological progress is to a great extent based on departures from the conventional or the status quo. That which is considered illogical or impossible to accomplish, has and always will be so only within the limited compass of accumulated knowledge up to a particular date. Speculative thinking is man's most precious asset. It is hoped that this department will provide an outlet for such thinking and will serve to stimulate further ideas. The implications of the symbolism for this department head are that: while the immediate worth of a concept may range from nil to infinity, its true value will only be determined in the ultimate.

# Electro-magnetic reaction

## can it be utilized as a means for propulsion in space?

by **Philip S. Egan**, industrial designer

MAGNETIC FIELD (ELECTRONIC) REACTION MEANS




M = MAINTAINED FIELD NORTH
C = COLLAPSING FIELD NORTH
G = GENERATING FIELD NORTH
m = MAINTAINED FIELD SOUTH
c = COLLAPSING FIELD SOUTH
g = GENERATING FIELD SOUTH

CY = FULL CYCLE (FREQUENCY TO BE THE OPTIMUM COMMENSURATE WITH THE RATE OF COLLAPSE OF AN ELECTRO-MAGNETIC FIELD X 3)

Given a system of electro-magnets as illustrated, with the N pole for the platform and S pole for the reactor. If the two poles were coupled in a phase-time relationship, their fields would be successively generated and collapsed in synchronized sequence as follows.

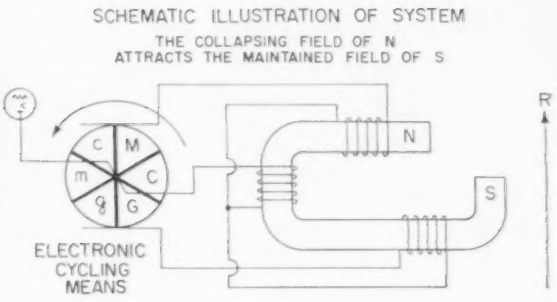
While maintaining the field of the S pole, the power of N is cut and its field collapsed. Next the field of S is collapsed while rebuilding the field of N.

Now the field of N is maintained while rebuilding the field of S, and the entire sequence is repeated continually.

Generating the field of N in a generally horizontal wave, and that of S in a vertical wave, the following can be assumed.

N, as a horizontally generated field, is disconnected from its parent structure at the instant of the power cut-off, but the now-isolated field, as it fades (from nearly 100 per cent to 0 per cent) is attracted to S, with its maintained field at that time. S, is however, connected to its parent structure; the tendencies of N and S to attract to a common half-distance are restrained, and the N field inertia attracts the S field and its entire parent structure toward N, for the duration of that part of the cycle.

SCHEMATIC ILLUSTRATION OF SYSTEM




Cycled on a high-frequency pattern, this system would generate lift in a period whose base is the speed of electricity. It would require a double electronic circuit, with the N and S phased to generate the extra ½ resultant (the distance that the S field cannot instantly move to meet the downward moving N field) in a frequency determined by the rate of collapse of an electro-magnetic field times three (see graph).

A system such as this might generate lift sufficient to lift a space vehicle from the gravitational field of a planet, or at least to accelerate a ship for an extended length of time from a satellite station (or after a boosted take-off from a planet) achieving the quasi-gravity and eventual very high velocity so desirable in space travel.

## DESIGN

**Control in Man-Machine Systems.**

G. W. HOOVER. *Control Eng.*, (March 1958), 4 pp.
Review of types and functions for current control systems, and a comparison between manned and unmanned systems used in weaponry.

**Intake-Ducts.**

A. F. WATTS. *Acft. Prod.*, (April 1958), 6+ pp.
Design and manufacturing aspects of integrally-stiffened air-intake ducts for the Lockheed F-104 aircraft.

**Optimization Study Missile Auxiliary Power Systems.**

E. I. BROWN and R. W. MCJONES. *SAE paper #48D*, (April 8-11, 1958), 15 pp.
Current energy-sources and power-conversion units are discussed as viewed by the equipment supplier.

**A4D Skyhawk.**

*Flight*, (March 7, 1958), 4 pp.
A review of its evolution and certain design features.

**Which Rate Gyro to Use?**

H. STERN. *Control Eng.*, (February 1958), 3 pp.
Description of various types of gyros as applicable to airborne automatic-control systems.

**Selection of Optimum Modes of Control for Aircraft Engines.**

A. J. SOBEY. *SAE paper #49A*, (April 8-11, 1958), 19 pp. Discussion of basic control requirements for turbojet engines by classifying regimes of operation in accordance with their primary objectives: physical limiting, thrust, and transient control.

## MATERIALS and PROCESSES

**Fusion Welding of Titanium.**

*Amer. Mach.*, (April 7, 1958), 3 pp.
Joint design and welding parameters given.

**Which Adhesive for What?**

R. W. JAMES and R. W. GORMLY. *Prod. Eng.*, (March 17, 1958), 3 pp.
Concise information given on types, properties and sources.

**Flame-Sprayed Ceramic Coatings.**

T. A. DICKINSON. *Production* (March 1958), 2 pp.
Brief description of process as practiced at Ryan Aeronautical Co.

**Machining Nonferrous Metals.**

*Iron Age*, (April 24, 1958) 16 pp.
Machining practice as applicable to aluminum, magnesium, and copper alloys, also to titanium covered. Hints are also given on proper tooling, speeds and feeds, depth of cut, lubricants and coolants.

**Use of Adhesives in the Aircraft Industry.**

W. K. BAILEY. *SAE paper #34B*, (March 31-April 2, 1958), 12 pp.
Discussion on the use of adhesives on the Convair B-58 bomber.

**Behavior of Metals under High-Energy Loads.**

T. A. DICKINSON. *Tool Engr.*, (March 1958), 4 pp.
Available information on the behavior of metals under explosive (forming) forces is summarized.

**Tooling with Plastics.**

V. L. FULCHINO. *Mach.*, (April 1958), 5 pp.
Typical applications given for

the production of close-tolerance parts used in small aircraft engines.

**Willing and Able Exotic Metals Seek Employment.**

A. R. GARDNER. *Prod. Eng.*, (March 17, 1958), 5 pp.
The properties and possible applications given for nine such metals.

**Corrosion and Oxidation-Resistant Coatings for Metals for Operation at Temperatures from 1000° F to 2400° F.**

J. V. LONG. *SAE paper #46C*, (April 8-11, 1958), 14 pp.
Background information on coating development, and discussion of Solar Aircraft Company's research on coatings for metal protection up to 2400°F.

**Bonding Magnesium.**

B. A. FORCHT. *Acft. Prod.*, (April 1958), 7 pp.
Process and evaluation data given on technique for the bonding of magnesium alloy sheet at Chance-Vought Aircraft, Inc.

**Hot Spinning Titanium.**

*Production*, (April 1958), 1 pp.
Brief description of process as applied to production of missile pressure-tanks.

## PRODUCTION

**Hot Precision Forgings and Extrusions.**

J. F. MURPHY. *SAE paper #36C*, (March 31-April 2, 1958), 18 pp.
Attributes of precision-gear forging, rotary forging and cross extrusion processes are examined.

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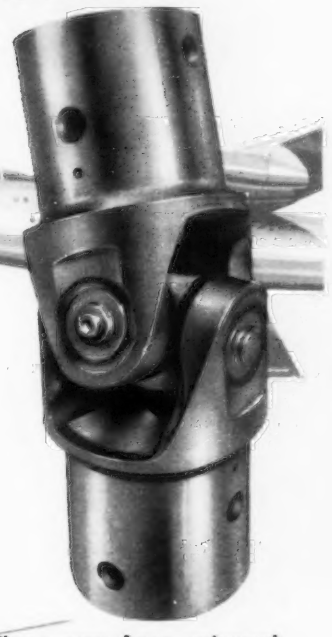

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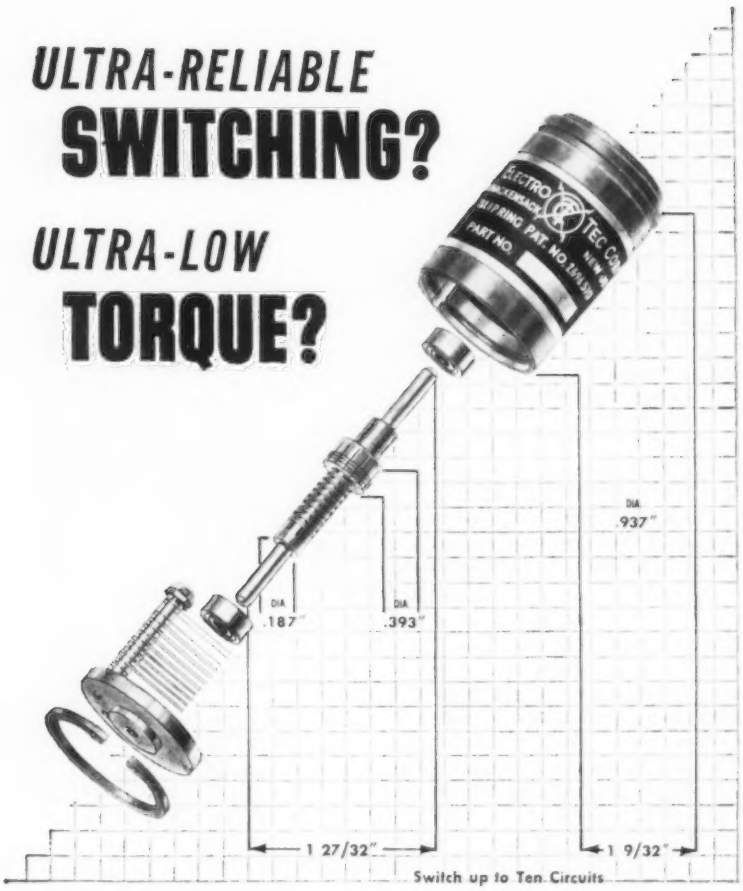


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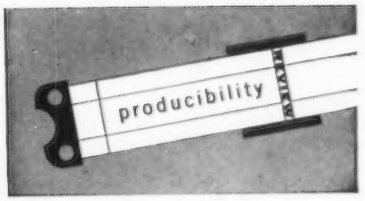



**Milling Jet-Engine Blades—Eighteen Seconds per Piece.**

C. O. HERB. *Mach.*, (March 1958), 5 pp.
Description of automated process and machinery.

**Powder Metal Shanks Reduce Chatter.**

C. G. ERICKSON. *Tool Engr.*, (March 1958), 3 pp.
Design of tools and methods discussed for difficult internal machining operations.

**"Bladder Molding" Forms Smooth Plastic Laminates.**

J. A. BAGLEY and F. M. PARTRIDGE. *Amer. Mach.*, (April 7, 1958), 2 pp.
Novel setup permits making a lay-up of preimpregnate over male plug, expanding plug by air pressure to conform to smooth walls of enveloping female mold.

**Rotary Extrusion Reduces Costs and Saves Material.**

J. GENIS and W. MALLINDINE. *Mach.*, (April 1958), 7 pp.
Production of jet-engine components by the cold power-spinning, or power roll-forming method discussed.

**REVIEWED IN THIS ISSUE**

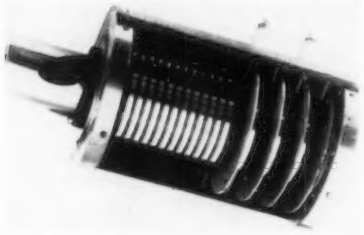
**Periodicals and Papers**

Acft. Prod. Aircraft Production (British)
Amer. Mach. American Machinist
Control Eng. Control Engineering
Flight Flight (British)
Iron Age Iron Age
Mach. Machinery
Production Production
Prod. Eng. Product Engineering
SAE Society of Automotive Engineers
Tool Engr. Tool Engineer

# materials / components

## Centrifuge Slip Ring Produced for Missile Test

A centrifuge slip ring designed for use with exceedingly high voltage has three circuits



capable of handling 10 kv dc continuously. Minimum noise is attained through the use of precious metals.

The assembly is rated at 350° F continuous operation. All 15 slip rings and shielded wires are high pressure molded into one integral assembly to offer protection against shock, vibration and humidity. These assemblies, ball bearing mounted and sealed, can provide 10 to 15 million revolutions of noise-free operation at 6000 rpm.

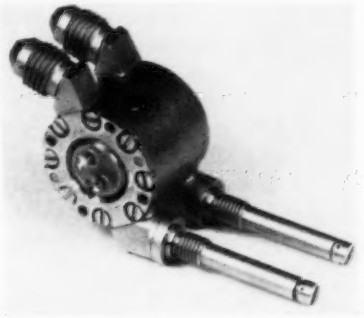
*Slip Ring Co. of America*

Circle 118 on postcard for more data

## Pressure Transducer Measures LOX Pressures

A new pressure transducer has been designed for measuring liquid oxygen differential pressures in missile and other rugged cyrogenic applications.

Known as the Model S-15, the unit is a dual coil, diaphragm type, differential pressure transducer. The gage features pneumatic symmetry to give a true indication of differential pressure despite any transient flow conditions.



A high output permits the use of direct reading instruments and use in control systems without amplification.

*Ultradyne, Inc.*

Circle 119 on postcard for more data

## Two Hi-Temperature Alloys Announced

Two new high-temperature alloys for use in the jet and missile age, designated D-979 and AF-71, have been produced in billets, bars, sheet, wire and forgings. Both alloys are now available in experimental quantities on a developmental basis.

Alloy D-979 is a nickel-chromium based material produced by the consumable electrode vacuum melting process pioneered by Allegheny Ludlum. It is designed for applications requiring high strength at temperatures up to 1600° F.

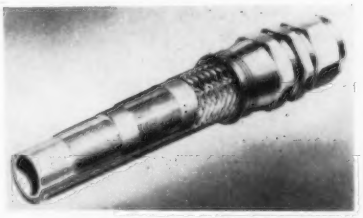
Alloy AF-71, is a comparatively inexpensive high-temperature, high-strength alloy with outstanding creep-rupture properties in the 1000 to 1500° F range. It is an iron-chromium-manganese material with low strategic alloy content.

*Allegheny Ludlum Steel Corp.*

Circle 101 on postcard for more data

## Spiral-Wrap, High-Pressure Hose of Teflon

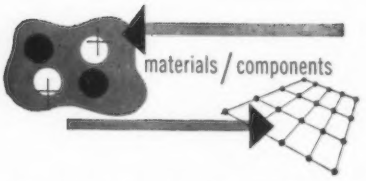
A high pressure hose of Teflon features a spiral wrap



construction engineered for lasting strength and resistance to impulse fatigue. The hose is designed for 3000 psi aircraft systems. The spiral construction prevents brinelling of the stainless steel wire and eliminates wire stress concentration.

"Super gem" fittings permit hose make-up assemblies in the field, and allow speedy alter-

*continued on next page*




ations in length when changes in hose dimensions are required.

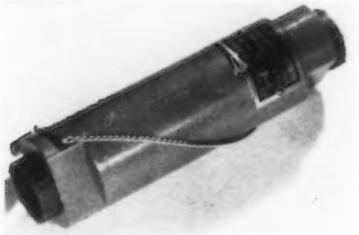
A metal-to-metal line seal in the fitting, combined with a lip seal formed by the tube of Teflon between the nipple and the sleeve of the fitting, assures positive grip and lasting protection against fitting blow-off.

*Aeroquip Corp.*

Circle 108 on postcard for more data

## Hydraulic Relief Valves Can be Operated at 650° F

A family of inline hydraulic relief valves designed to



operate in high performance aircraft systems has qualified under MIL-V-5523B. The valve may be modified for temperatures to 650° F, since it does not employ a dynamic elastomer. A built-in dash pot dampens out any tendencies for the valve to become unstable from cracking to extremely high flow.

The flow capacity of the ½ in. valve is comparable to the MS 28887 ¾ in. valve with approximately half the pressure differential between full flow and reseat.

*Arkwin Industries, Inc.*

Circle 109 on postcard for more data

## Bellows-Type Shaft Seal Uses Teflon Construction

A bellows-type, end-face, shaft seal, in which only Teflon is exposed to the liquid being sealed is designed for use where chemicals increase the corrosion rate of seal parts normally made of metal.

The main sealing member is a bellows of pure Teflon integrally molded with a sealing face of filled Teflon.

For internal mounting, a double-ended seal is employed. For external mounting, a single-faced seal is used, and the rotating member is secured to the shaft with a metal clamping ring.

*Crane Packing Co.*

Circle 117 on postcard for more data

## Fuel Control Units Available for Gas Turbine Drones, Missiles, Aircraft

A series of light-weight, low-cost, fuel controls suitable for use on small gas turbine powered aircraft, missiles and target drones is available as the Model MC fuel control series.

Each unit incorporates a pneumatic speed governor which enables it to maintain constant speed from sea level to 60,000 ft.

All versions in the MC series are approximately the same size and vary in weight from 7 to 10 lb.

Remote control, when required, is accomplished by means of an electric actuator mounted on the control unit.

*Pratt & Whitney Co.*

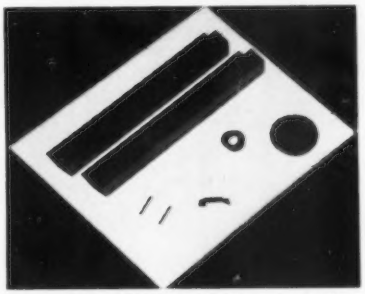
Circle 106 on postcard for more data

## Ferrites Available For Microwave Components

The availability of two new types of ferrites for microwave and other applications has been announced. They are sintered oxides of such metals as nickel, magnesium, and manganese, and are blended, sintered and finished within a tolerance of 0.0005 in.

Type N-50 ferrites, designed for use in electro-mechanical filters, offer an extremely low temperature coefficient with a resonant frequency change of less than 35 cycles/megacycle/°C over a temperature range of —40 to 85° C.

Type N-51 ferrites, useful in transducers, are especially



suited for hydrophones and similar devices requiring low power.

*Kearfott Co., Inc.*

Circle 105 on postcard for more data

## Silicone Fluid Lubricates Bearings at 600° F for 50 hr

Despite operation at 600° F under rigorous test conditions, this 150 mm jet engine bearing shows no visible signs of degradation. Run in Versilube 81644 silicone lubricating fluid for 50 hr, the bearing was operated at 7100 rpm under a 5000 lb axial load.

Test was one of a series on silicone fluids being conducted for design engineers in

General Electric's aircraft gas turbine engine operations at Evendale, Ohio.

Tests have shown the Versilube fluids offer excellent potential as high temperature lubricants for jet engines.

The Versilube fluids are characterized by good thermal and oxidative stability in the 500 to 700° F temperature range.

*General Electric Co.*

Circle 111 on postcard for more data

# meeting AN-MS-NAS Specifications for AIRCRAFT or SPACECRAFT

**ARNAV . . .**

- OPERATES PLANTS on both East and West Coasts.
- MAINTAINS LARGEST STOCKS of hydraulic fittings on entire Eastern Seaboard.
- MAINTAINS LARGE STOCKS of forgings and bar stock — for fabrication into complete fittings with maximum speed.
- DESIGNS and PRODUCES SPECIAL FITTINGS to very close tolerances to your drawing specifications.
- OWNS ITS OWN TOOLS AND DIES to speed delivery to you on special designs.

- FABRICATES FROM ALMOST ANY METAL: 303, 347 and other stainless steels; 14ST, 17ST, 61ST, other aluminum grades; C1137, 4130 and other steels; brass, titanium, magnesium and Duronze.
- MEETS OR EXCEEDS MIL-F-5509 specs; maintains inspection and quality control standards in conformance with MIL-Q-5923.
- WRITE, PHONE OR WIRE for prompt delivery on your standard requirements — and quotations on specials.

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***Mail Coupon*** FOR CONVENIENT 17 x 22 WALL CHART on A-N, MS and NAS HYDRAULIC FITTINGS — and for the basic background story on your most-fitting source of supply.

Please send me your Hydraulic Fittings Wall Chart and information on your company facilities.

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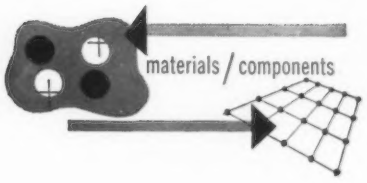
AMMS


Circle 42 on Inquiry Card, page 65




## Hydraulic Pump Gives Pressures to 5000 psi

The first of a new line of 11-cylinder hydraulic pumps is announced by Vickers Incor-

porated. This unit provides pressure to 5000 psi and delivers 15.8 gpm at 6220 rpm. Both variable and fixed displacement models are available.

The new series attempts to fulfill the aircraft industry's requirements for increased flow rates, higher pressures and greater rotative speeds with improved reliability.

*Vickers Inc.*

Circle 110 on postcard for more data

## Electrical Wiring Coated with Teflon

Bronco 500 electrical hook-up and lead wire, insulated with Teflon has an operating temperature range of from —90 to 250° C. It is impervious to most chemicals and solvents and has very low moisture absorption.

Made with silver-plated, stranded copper conductors, it

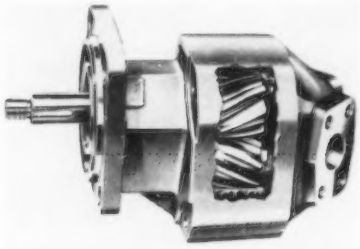
eliminates cracking at low temperatures and permits runs of unlimited length. Bronco 500 is made in a.w.g. sizes 20, 18, 16, 14, 12, and 10 and is available in all colors, solid and striped combinations.

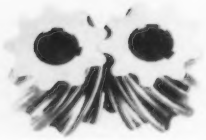
*High Temperature Div., Western Insulated Wire Co.*

Circle 120 on postcard for more data

## Gear Hydraulic-Pump Prevents Fluid Trapping

A high-speed hydraulic pump, designated the Hydroid pump, features gears with an





elliptical profile to eliminate trapping of liquid between teeth.

The non-trapping feature permits speeds in excess of 4000 rpm with hydraulic pressures of more than 1500 psi. Flow rates from 3 to more than 250 gal/min are attainable.

Ability to operate at high speeds eliminates need of costly reduction gearing accessories on hydraulic applications.

*Hupp Aviation Co.*

Circle 115 on postcard for more data

## Unitized Fuel Control Designed for Helicopters

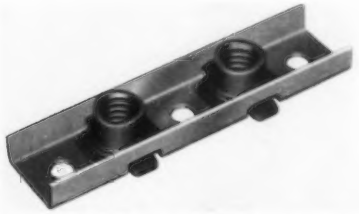
A unitized fuel control designed especially for helicopter powerplant installation is known as the TA-1. The compact package weighs approximately 30 lb. It houses a computer system, a fuel metering system, and a power turbine governor enabling the control to maintain desired engine speeds from sea level to 30,000 ft under varying conditions of pressure and temperature. Either element of a dual element gear pump is capable of delivering full fuel requirements.

*Chandler-Evans Div., Pratt & Whitney Co., Inc.*

Circle 107 on postcard for more data

## Simple, Inexpensive Fastener Provides Strength, Ductility

Weight reductions to 76 per cent, plus high ductility have been provided in a new hex nut fastener. The new series, in thread sizes 10-32 and ¼-28, is designed to carry the same loads as heavier hex nuts.



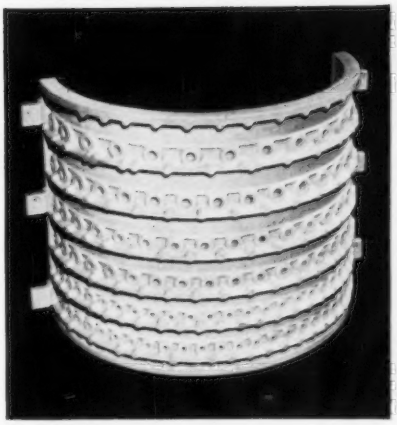
Ductility tests show that when these nuts are squeezed in the jaws of a vise they "fold" together without cracking. They are made in alloy steel, with a special heat treatment to achieve unusual ductility and still meet MIL-N-25027 requirements.

*Nutt-Shel Co., Inc.*

Circle 104 on postcard for more data

*Advertisement*

**Zirconium, thorium, cerium . . . strange names for little known, little used elements. But add them to magnesium, and a new family of metals appears. Preserving the high strength-weight ratio of the featherweight metal, they add high-temperature properties that have proved a necessity in high performance aircraft and missiles. A specialist in light metals casting, Rolle knows these alloys as you know the back of your own hand.**



# how to save weight at high temperatures

## *an introduction to the magnesium-rare earth-thorium alloys*

One-fourth the weight of steel . . . two-thirds the weight of aluminum . . . magnesium has carved a featherweight niche for itself in modern materials engineering.

But the reputation won by the magnesium-aluminum zinc alloys was won at room temperatures. Where high temperatures obtain, the "structural" alloys are no longer structural, and the lesser known "premium" group comes into its own.

These alloys, providing excellent high temperature properties and creep resistance to 660F, are also characterized by

- uniform strength of varying cross-section
- high fatigue strength
- low notch sensitivity
- freedom from microporosity
- good stress rupture characteristics
- good founding qualities

Naturally, properties vary within the group, but a rough comparison of individual advantages can be drawn.

*a profile of the "premium alloys"*

ZK51A and ZE41XA are superior, fine grained alloys with high yield strength and ductility, excellent fatigue properties, low notch sensitivity, and they are pressure tight without impregnation. Alloy ZH62XA offers these same general properties but is stronger than ZK51A. The room temperature strength of ZH62XA is combined in a relatively new alloy, ZH42, with creep resistance to 480F.

Complete freedom from microporosity, excellent founding properties, and low heat treating temperatures, characterize EZ33A, a magnesium-zirconium-cerium alloy. Like ZH42, EZ33A resists creep to 480F, and possesses good tensile properties at both normal and elevated temperatures.

HZ32A, perhaps the most important alloy of the series, contains thorium rather than cerium. Equal to EZ33A in strength, founding properties, and heat treating characteristics, it resists creep to 660F.

*ideal for engine castings*

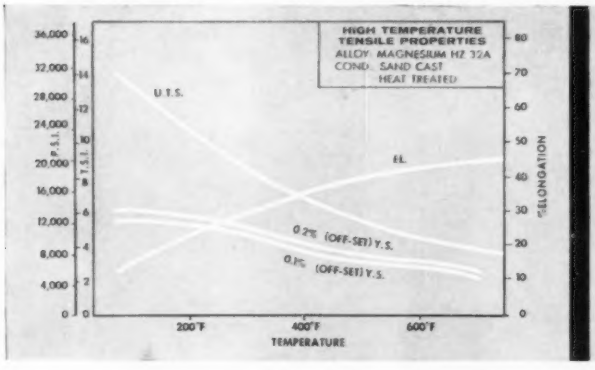
Though each of these "premium" alloys offers specific advantages, the benefits of HZ32A have undoubtedly been most impressive. Its unique heat resistance properties permit weight savings in stressed turbine engine parts with magnesium castings for the first time. A typical example is the part illustrated above . . . a jet engine compressor housing . . . sand cast by Rolle in HZ32A. Success of this alloy in such applications can be inferred from the two graphs—High Temperature Tensile Properties and Creep Resistance For Specified Plastic Strains.

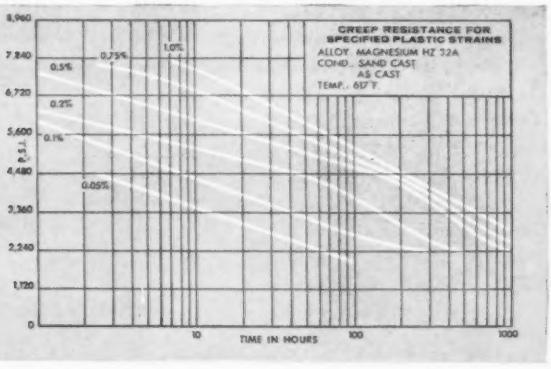
*maintaining specified properties*

Chances are you spend hours . . . even days . . . studying the "book" specifications of a metal before you design it into a part. But the book you've been working with too often gets thrown out the window with the first production run. Getting the most out of the premium alloys and into the cast part is often a difficult task, but we feel we're in an ideal position to do just that. Sand, shell, and permanent mold casting the *light metals* . . . and *only* the light metals . . . is our business.

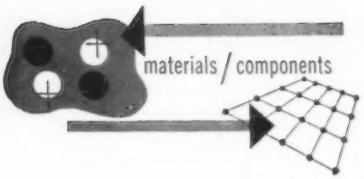
*fifty-eight page engineering manual*

A considerable amount of data on the design properties of the aluminum and magnesium alloys can be found between the covers of our light metals casting manual. We'll gladly send you a copy on letterhead request. Write Rolle Manufacturing Company, 317 Cannon Avenue, Lansdale, Pa., or call ULlysses 5-1174.




ROLLE




## Regulator Safeguards Electronic Equipment

An air pressure regulator, used to prevent self-destruction of electronic guidance equipment on guided missiles, maintains approximate sea level pressure in an electronics compartment. This prevents destructive electrical arcing at the low pressures encountered in the missile environment.

The unit weighs ¾ lb, measures 3 in. high, with a housing diam of 2¼ in. and an attachment flange diam of 4 in.

The unit is an outflow valve operated by a spring and bellows arrangement.

*Garrett Corp.*

Circle 113 on postcard for more data

## Ceramic Coil Forms Have Pre-Set Torque Spring Lock

Designed for both military and commercial applications, a new line of ceramic coil forms is comprised of five standard sizes; each available with or without terminal collars; each terminal collar accepting up to four terminals per collar.

An internal, pre-set torque spring positions and locks the adjusting cores thus keeping coils tuned as set, even under severe vibration and shock.

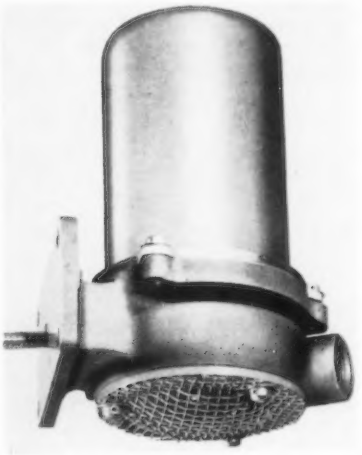
*National Company, Inc.*

Circle 103 on postcard for more data

## Submerged Booster Pump For Drone and Missile Use

Consisting of a centrifugal pump, an electric motor and a radio noise filter, this low-cost, submerged fuel booster pump is designed for vertical mounting on the fuel tank wall of target drones and missiles.

Pumping fuel per MIL-F-5624 it has a rated flow of 300 pph, with a 14 psig discharge



pressure. The unit is built for a 50 hr minimum continuous operation life at the rated conditions. It will operate in a fuel temperature range from —65 to 110° F and altitudes from sea level to 45,000 ft.

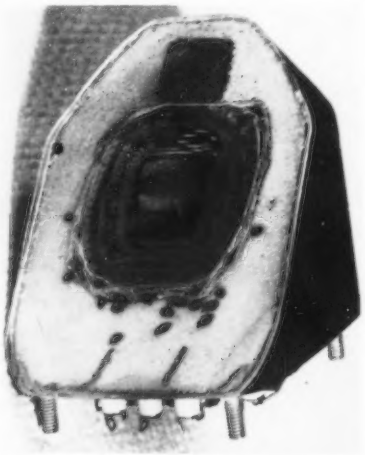
The motor is rated at 0.06 hp, 10,000 rpm, 26.5 v/dc, with a current drain of 3.8 amp.

*Lear, Inc.*

Circle 114 on postcard for more data

## Foam-in-Place Epoxies For Electrical Components

Two foam-in-place epoxy potting compounds now are



available for use in protecting electronic components where weight-saving is important. The low density, closed-cell epoxy foams maintain excellent electrical characteristics and mechanical strength. Available is Sealfoam 601, a two-component liquid, and Sealfoam 603, a single-component, free-flowing powdered material.

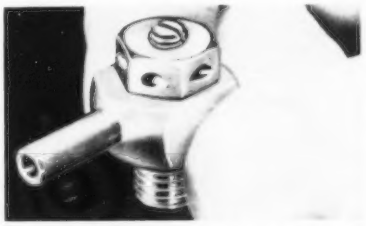
Picture illustrates use of the single-component compound in a small transformer where protection against vibration is required.

*Minneapolis Honeywell*

Circle 112 on postcard for more data

## Hydraulic Bleeder Valve Has 360 Deg. Positionable Discharge Aperture

A compact, hydraulic bleeder valve, designed for use in bleeding or purging lines in aircraft and hydraulic circuits features a discharge port that can be positioned in a 360 deg plane to simplify bleeding operations in confined working areas.



The unit operates in temperature ranges of —65 to 250° F.

It is manufactured in cadmium plated steel with 3/16 in. OD nozzle, and 5/16 in.—24 UNF thread connections. It can be made of other metals. Operating pressure is 3500 psi, proof pressure 7000 psi and burst pressure 14000 psi.

*Fluid Regulators Corp.*

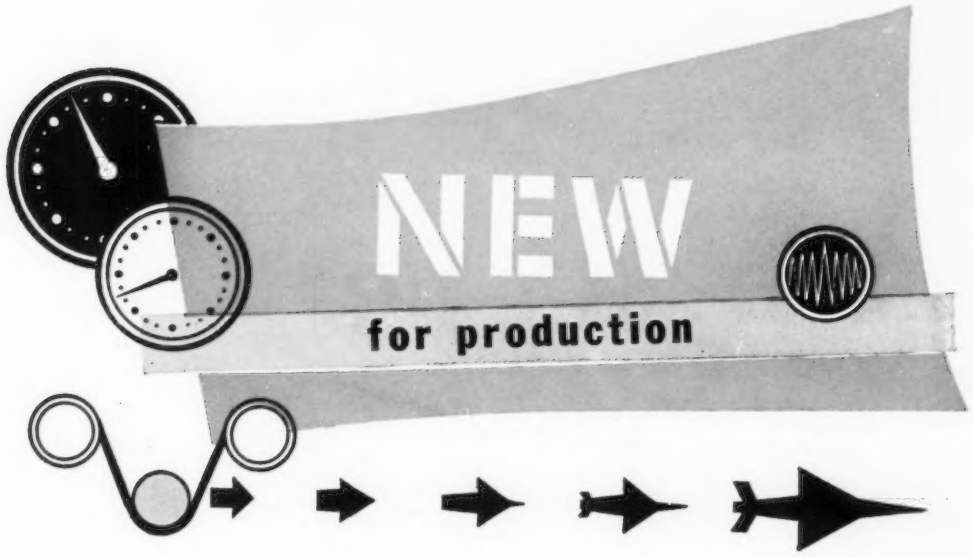
Circle 102 on postcard for more data

## Man-made Rubber

Ameripol SN a man-made rubber with the same molecular structure as natural rubber can be used interchangeably with natural rubber for making aircraft and missile tires and tubing.

*B. F. Goodrich Co.*

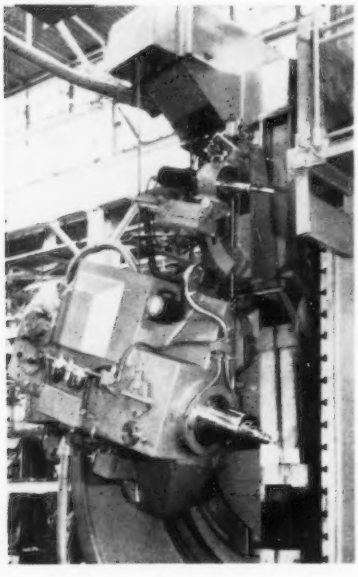
Circle 116 on postcard for more data




## TILTING HEAD ON AUTOMATIC MILLER

A new type Keller automatic tracer-controlled milling machine with a special milling head that can be tilted 20° above or below the horizontal position has been developed.

The new miller was designed for profile milling of "warped" surfaces encountered in many aircraft components which must be accurately profiled to conform with the contours of the aircraft's outer surface. It is a modification of the BG-22 Keller used extensively in the automotive and aviation industries for the production of large dies and molds and for milling forged parts.



The Keller weighs more than 75 tons. A template mounted parallel to the horizontal motion of the machine controls the angle of tilt through servo action.

The operator's control panel is contained in an independent electrically powered elevator.

*Pratt and Whitney Co.*

Circle 128 on postcard for more data

## NEW FLOOR MODEL TURRET DRILL

Manufacturers who drill, tap, counterbore, ream or otherwise machine small holes (up to ¼-in. diam in steel) are offered a new floor model turret drill. Several features specifically adapt this tool to high production jobs, eliminating time normally wasted moving part and jig from machine to machine or spindle to spindle.

A series of six different operations can now be performed from one work location with a six station turret. The power indexed turret rotates itself, and only the spindle in use is in operation. As the head reaches top position on the vertical columns, indexing is triggered automatically. Each spindle, however, will repeat any number of feed strokes without indexing, if duplicate hole sizes or operations are desired.

Two-step pulleys on the motor drive produce two complete speed ranges on each spindle.

*Burgmaster Corp.*

Circle 131 on postcard for more data

## QUALITY CONTROL TOOL FINDS MISSILE WEIGHT

Missiles or missile components can be weighed, and measured for center of gravity, by a single unit locator.

Intended primarily for

*continued on next page*

smaller missiles, the design, about eight ft long, can handle missiles or components up to seven ft apart and weigh to 1100 lb. Guaranteed accuracy is total weight to .15 lb and c.g. to within .01 in.

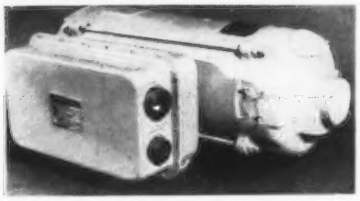
Presentation is either visual, printed, or both. Readings are either vertical reactions at two longitudinal stations or total weight and c.g. displacement from a predetermined reference station.

The device is an application of a resolution electro-mechanical force beam developed in wind tunnel measurements.

*Dynametrics Corp.*

**Circle 127 on postcard for more data**

## ALTERNATOR FOR MULTIPLE USES



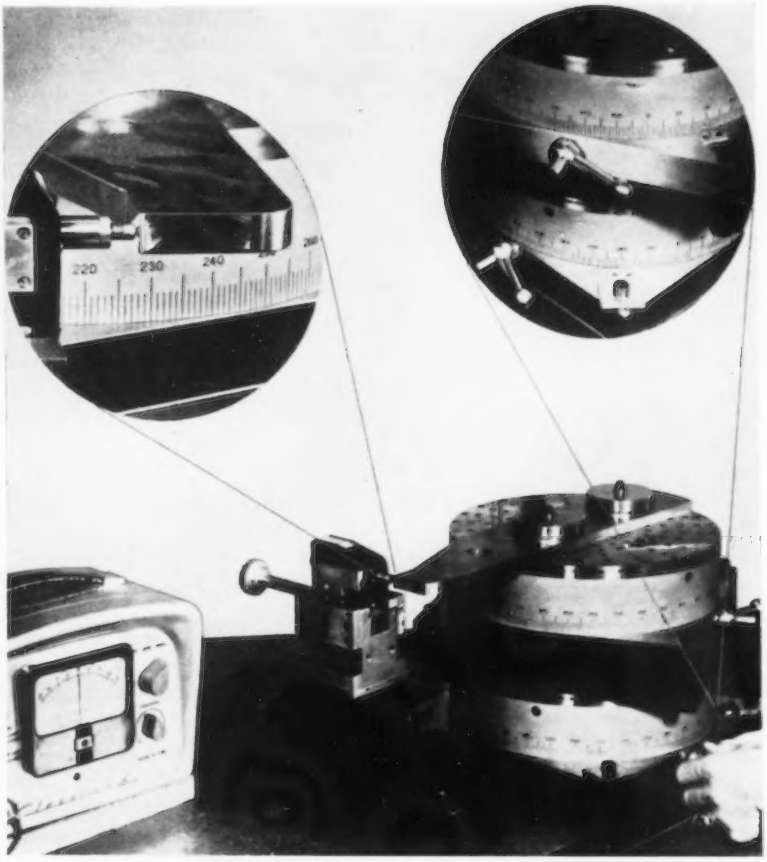
A high performance motor alternator set designed to meet strict requirements for ground power, test and missile ground checkout equipment has been developed. Relatively small size and low weight also make it suitable for air transport, machine tool, and laboratory.

Alternator set can convert either variable voltage DC or variable voltage and frequency AC to closely controlled constant voltage and frequency AC. It is designed for 5000 hours continuous duty with only normal brush maintenance.

The set, with about 8½-in. diam, is 25-in. long and weighs about 230 lb.

*General Electric Co.*

**Circle 129 on postcard for more data**




## NEW PRINCIPLE AIMS AT LAB ACCURACY

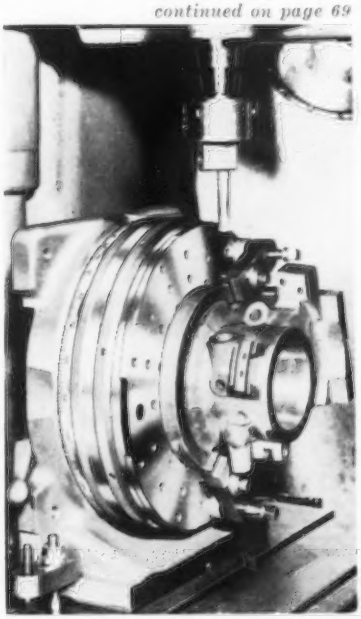
A new dividing head breaks down the arc to within fractions of a second in less than a minute.

The new development obtains fractional accuracies through a concept that consists of hundreds of angular-plane mating surfaces, making contact at each one of the 360° settings with an equal number of the meticulously accurate mating surfaces. Each time the head is indexed, accuracy is assured, not by one or two mating surfaces, but by hundreds.

Developed over a period of six years as the result of an experience with a jet engine ring during the Korean conflict, the new indexing principle includes two 12-in. diam tables, one atop the other. The top table has a 12-in. arm extending from its center (providing a 24-in. diam check) to a fixture holding a jeweled contact point which, in turn, is connected to an electronic dial indicator graduated into millionths of an inch.

In cross-checking tests,

*continued on page 69*



To keep well informed on new products and production equipment, use AIRCRAFT and MISSILES MANUFACTURING'S free reader inquiry service. The new materials, components, technical literature, and production equipment advertised and described editorially in this issue are numbered consecutively and keyed to the post cards below. When information is wanted, circle the corresponding key number on the post card. Extra cards are included for your associates with whom you share your copies of AIRCRAFT and MISSILES MANUFACTURING.

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# advertisers in this issue

**In order to obtain further details on items advertised or described in this issue, circle the key number (s) on the postpaid card and mail it.**

32 **American Ordnance Association**
Membership, association
40 **Apex Machine & Tool Co.**
Joint, universal, anti-friction
42 **Arnav Aircraft Associates, Inc.**
Fittings, hydraulic
30 **Burgmaster Corp.**
Drill, bench model, turret
31 **Electric Steel Foundry Co.**
Castings, centrifugal
41 **Electro Tec Corp.**
Assemblies, switch, miniature
39 **Gear Grinding Machine Co.**
Grinders, precision
44 **Hamilton Tool Co.**
Hobbers, gear
46 **Hunter Mfg. Co.**
Torches, instant lighting
35 **Le Blond Machine Tool Co., R. K.**
Lathes, new
28 **Magnaflux Corp.**
Systems, test
34 **Menasco Mfg. Co.**
Process, unwielding
50 **Narda Ultrasonics Corp.**
Equipment, ultrasonic, cleaning
37 **Nutt-Shel Co., Inc.**
Nut, timesaver
33 **Rolle Mfg. Co.**
Magnesium
45 **Sealol Corp.**
Joints, swivel, custom-designed
36 **Sharon Steel Corp.**
Steels, specialty
38 **Shell Oil Co.**
Lubricants, ultra-high temperature
19 **Sonnet Tool & Mfg. Co.**
Cutters, standard
43 **Stackpole Carbon Co.**
Brushes, quick filming
47 **Sturtevant Co., P. A.**
Manual, torque wrench
29 **Temco Aircraft Corp.**
Titanium
48 **U. S. Flexible Tubing Co.**
Flexducts & bellows, stainless

## MATERIALS AND COMPONENTS

### Alphabetical List of Products

101 **Alloys, high temperature**
Allegheny Ludlum Steel Corp.
102 **Bleeder valve, hydraulic**
Fluid Regulators Corp.
103 **Coil forms, ceramic**
National Company, Inc.
104 **Fastener, Timesaver**
Nutt-Shel Co., Inc.
105 **Ferrites, electronic**
Kearfott Co., Inc.
106 **Fuel control, gas turbine**
Pratt & Whitney Co.
107 **Fuel control, helicopter**
Chandler-Evans Div.
Pratt & Whitney Co., Inc.
108 **Hose, wire-wrap Teflon**
Aeroquip Corp.
109 **Hydraulic relief valve**
Arkwin Industries Inc.
110 **Hydraulic pump, 11-cylinder**
Vickers, Inc.
111 **Lubricant, silicone (Versilube)**
General Electric Co.
112 **Potting compounds, epoxie**
Minneapolis Honeywell
113 **Pressure regulator, air**
Garrett Corp.
114 **Pump, booster**
Lear, Inc.
115 **Pump, hydraulic, hydroid**
Hupp Aviation Co.
116 **Rubber, man-made**
B. F. Goodrich Co.
117 **Shaft seal, Teflon**
Crane Packing Co.
118 **Slip ring, Centrifuge**
Slip Ring Co. of America
119 **Transducer, pressure measuring**
Ultradyne, Inc.
120 **Wire, electrical, Teflon coated**
High Temperature Div.
Western Insulated Wire Co.

### Alphabetical List of Companies

108 **Aeroquip Corp.**
Hose, wire-wrap Teflon
101 **Allegheny Ludlum Steel Corp.**
Alloys, high temperature
109 **Arkwin Industries Inc.**
Hydraulic relief valve
117 **Crane Packing Co.**
Shaft seal, Teflon
102 **Fluid Regulators Corp.**
Bleeder valve, hydraulic
113 **Garrett Corp.**
Pressure regulator, air
111 **General Electric Co.**
Lubricant, silicone (versilube)
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Rubber, man-made
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Pump, hydraulic, hydroid
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138 **Glossary, instrumentation**

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114 **Lear, Inc.**
Pump, booster
112 **Minneapolis Honeywell**
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103 **National Company, Inc.**
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104 **Nutt-Shel Co., Inc.**
Fastener, Timesaver
107 **Chandler-Evans Div. Pratt & Whitney Co., Inc.**
Fuel control, helicopter
106 **Pratt & Whitney Co.**
Fuel control, gas turbine
118 **Slip Ring Co. of America**
Slip ring, Centrifuge
119 **Ultradyne, Inc.**
Transducer, pressure measuring
110 **Vickers, Inc.**
Hydraulic pump, 11-cylinder
120 **High temperature Div., Western Insulated Wire Co.**
Wire, electrical, Teflon coated

## NEW FOR PRODUCTION

### Alphabetical List of Products

121 **Balancing machine, dynamic**
Tinius Olsen Testing Machine Co.
122 **Counter, electronic**
Lavoie Laboratories, Inc.
123 **Dividing head, arc measurement**
A. A. Gage Co.
124 **Engraver, column type**
Franz Kuhlmann KG
125 **Gage head, sealed**
Federal Products Corp.
126 **Gaging Machine, for holes**
The Sheffield Corp.
127 **Locator, weight and c.g.**
Dynametrics Corp.
128 **Milling machine, automatic**
Pratt & Whitney Co., Inc.
129 **Motor alternator**
General Electic Co.
130 **Production table, circular**
The Dumore Co.
131 **Turret drill, floor model**
Burgmaster Corp.

### Alphabetical List of Companies

131 **Burgmaster Corp.**
Turret drill, floor model
130 **The Dumore Co.**
Production table, circular
127 **Dynametrics Corp.**
Locator, weight and c.g.
125 **Federal Products Corp.**
Gage head, sealed
123 **A. A. Gage Co.**
Dividing head, arc measurement
129 **General Electric Co.**
Motor alternator
124 **Franz Kuhlmann KG**
Engraver, column type
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Balancing machine, dynamic
128 **Pratt & Whitney Co., Inc.**
Milling machine, automatic
126 **The Sheffield Corp.**
Gaging machine, for holes


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## WORTH ASKING FOR

### Alphabetical List of Items

132 **Amplifiers, I.F.**
Lel, Inc.

133 **Brazing, manual of**
All-State Welding Alloys Co.

134 **Brush Beryllium, facts**
The Brush Beryllium Co.

135 **Chart, wall**
Ernest F. Donley's Sons, Inc.

136 **Clinch nuts, types of**
Elastic Stop Nut Corp. of America

137 **Data sheet, guided missile**
LaSalle Steel Co.

138 **Glossary, instrumentation**
Trans-Sonics, Inc.

139 **Label embosser, portable**
Dymo Corp.

140 **Lithium hydride, properties**
Foote Mineral Co.

141 **Materials Handling**
National Vulcanizing Fibre Co.

142 **Milling, Chemical**
Anadite, Inc.

143 **Plants, rectification**
Superior Air Products Co.

144 **Pressure pickups, subminiature**
Consolidated Electrodynamics Corp.

145 **Production, description**
Janitrol Aircraft Div., Surface Combustion Corp.

146 **Properties, investment cast**
Haynes Stellite Co.

147 **Relays, uses of**
Comar Electric Co.

148 **Rivets, high temperature**
Deutsch Fastener Corp.

149 **Samplers, air**
The Staplex Co.

150 **Sleeving and Tubing**
Birnbach Radio Co.

151 **Steel fabricating, cast alloys**
Alloy Casting Institute

152 **Transformer, variable**
The Superior Electric Co.

153 **Welding, Titanium**
Titanium Metals Corp. of America

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151 **Alloy Casting Institute**
Steel fabricating, cast alloys

133 **All-State Welding Alloys Co.**
Brazing, manual of

142 **Anadite, Inc.**
Milling, chemical

150 **Birnbach Radio Co.**
Sleeving and tubing

134 **The Brush Beryllium Co.**
Brush Beryllium, facts

147 **Comar Electric Co.**
Relays, uses of

144 **Consolidated Electrodynamics Corp.**
Pressure pickups, subminiature

148 **Deutsch Fastener Corp.**
Rivets, high temperature

135 **Ernest F. Donley's Sons, Inc.**
Chart, wall

139 **Dymo Corp.**
Label Embosser, portable

136 **Elastic Stop Nut Corp. of America**
Clinch nuts, types of

140 **Foote Mineral Co.**
Lithium hydride, properties

146 **Haynes Stellite Co.**
Properties, investment cast

145 **Janitrol Aircraft Div., Surface Combustion Corp.**
Production, description

137 **LaSalle Steel Co.**
Data sheet, guided missile

132 **Lel Inc.**
Amplifiers, I.F.

141 **National Vulcanized Fiber Co.**
Materials handling

149 **The Staplex Co.**
Samplers, air

143 **The Superior Air Products Co.**
Plants, rectification

152 **The Superior Electric Co.**
Transformer, variable

153 **Titanium Metals Corp. of America**
Welding, Titanium

138 **Trans-Sonics, Inc.**
Glossary, Instrumentation

the electronic indicator dial has demonstrated the equivalent of 1/10 sec accuracy.

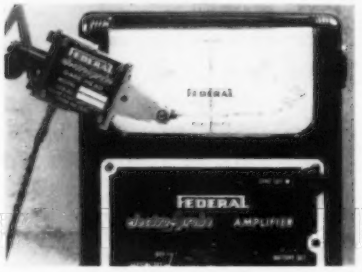
*A A Gage Co.*

Circle 123 on postcard for more data

## NEW GAGING SYSTEM

An electronic system of precision measurement uses a small hermetically sealed gage head, whose unique method of electromagnetic operation provides unusual operating capabilities.

Amplitude of the continuously produced electronic signal maintains such exact linear relationship to contact




movement that available electrical instruments have not had sufficient sensitivity to measure the error. Linear output is available over an exceptionally wide range of contact travel (.030 in.). Electrical and mechanical sensitivity is capable of providing magnifications and accuracies exceeding present precision gaging requirements.

The head, measuring approximately 1½ in. x 2½ in. x ½ in., can be used with various types of contacts and contact mountings, depending on the overall accuracy required and can be operated with several types of amplifiers according to needs. Gage heads are interchangeable and may be employed jointly or in rapid succession by switching.

*continued on next page*

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STACKPOLE CARBON COMPANY, St. Marys, Pa.
BRUSHES for all rotating electrical equipment • ELECTRICAL CONTACTS • BEARINGS • GRAPHITE CHEMICAL ANODES • GROUNDING ANODES • POWER TUBE ANODES • SEAL & CLUTCH RINGS • VOLTAGE REGULATOR DISCS • HEATING ELEMENTS • FRICTION SEGMENTS • CERAMIC MAGNETS • FERROMAGNETIC CORES • FIXED & VARIABLE RESISTORS • WELDING CARBONS . . . and many other carbon, graphite and metal powder products.



Circle 43 on Inquiry Card, page 65

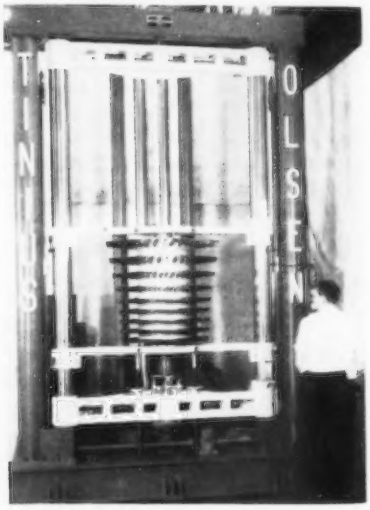
Transistor operation permits the unit to be completely independent of external power. Extremely light but positive gaging pressure (less than 5 gms) permits using the gage head on any type of conventional test stand, comparator base or holding fixture without danger of inaccuracy due to deflection of posts or arms.

*Federal Products Corp.*

Circle 125 on postcard for more data

## VERTICAL MACHINE BALANCES JET PARTS

For dynamically balancing jet engine turbines and compressors to within extremely close limits, the Type JDV-1000 Vertical Dynamic Balancing Machine has been announced.




Machine accommodates jet engine components up to 55 in. diam 90 in. length and 1000 lb. Parts can be balanced to within .0000145 in. displacement at the bearings. The amount and angle of unbalance in both planes of correction are accurately determined by means of a highly sensitive electrical compensating system. Operator can determine unbalance without stopping the machine by using two sets of controls.

*Tinius Olsen Testing Machine Co.*

Circle 121 on postcard for more data

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BUT MY WORK INCLUDES THE MANUFACTURE OF—

I KNOW! AND YOU CANNOT POSSIBLY BUY A BETTER MACHINE FOR THE JOB THAN—

THE HAMILTON No. 1-B PRECISION SMALL GEAR HOBBING MACHINE

INVESTIGATE IT! YOU'LL SEE!

SPUR GEARS, WORM GEARS, and SPIRAL GEARS (up to 6" O.D.)
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GEAR SECTORS
PINIONS
and FACE GEARS
and BEVEL GEARS (up to 3" O.D.)

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Hamilton

PRECISION SMALL-GEAR HOBBING MACHINE

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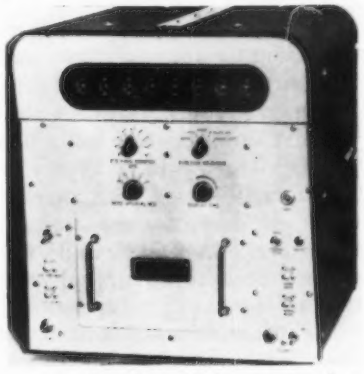
THE HAMILTON TOOL COMPANY • 882 SOUTH NINTH STREET • HAMILTON, OHIO

Circle 44 on Inquiry Card, page 65

## ELECTRONIC COUNTER FROM LAVOIE LABS



An electronic counter has been designed to provide the highest reliability, long life potential, and utilization of in-line

eight-place Nixie read outs of measured frequency or time intervals. The frequency range is from 10 cycles to 10 megacycles and the range of time intervals is from one microsecond to 100 days.

Giving increased performance and greater flexibility, the unit is designed to meet military requirements. It has simplified circuitry, controlled reset, automatic decimal point and temperature stability. High reliability is assured by a new concept in circuit design, utilizing magnetic beam switching tubes as decade dividers and scalers.

There are additional plug-in units available to increase the flexibility of the unit including frequency converter units, video amplifiers, extended time base units, relay test units and digital recorders.

*Lavoie Laboratories, Inc.*

Circle 122 on postcard for more data

## GAGING MACHINE FINDS HOLES IN PRECISION PARTS

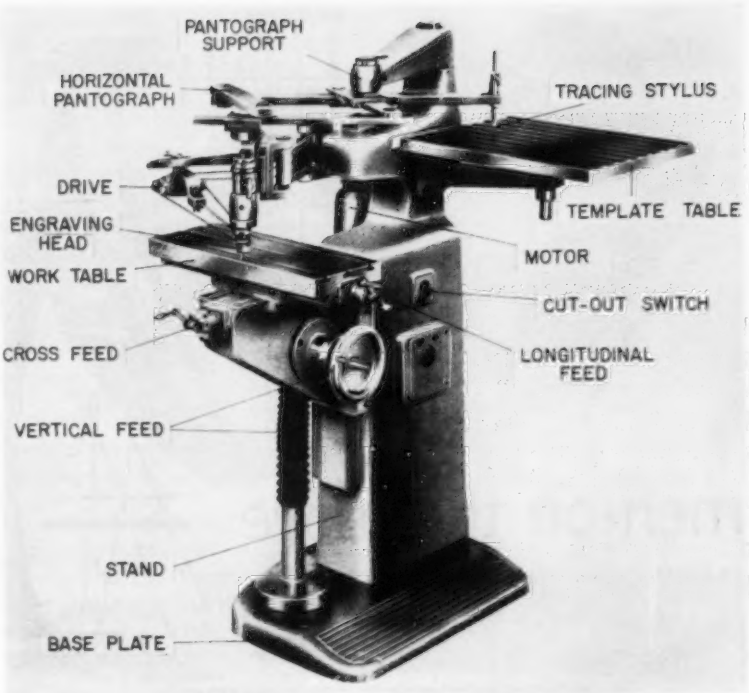
A precision gaging machine determines precise location of holes in precision-made parts such as bearing plates, and instrument stacks.

Designated the Precisionaire Hole Coordinate Measuring Machine, the gage consists of a heavy cast base on which is mounted a serrated worktable adjustable through both horizontal planes. Above the table is an overhanging arm that has a "Center-find" pickup stylus connected to a column instrument which amplifies and indicates gage reading.

The worktable is set to calibrated dimensions in both planes by gage blocks and micrometers. The four-in. diam barrel micrometers have one-in. gaging range and are graduated in ten millionths.

*The Sheffield Corp.*

Circle 126 on postcard for more data




## VERSATILE ENGRAVING MACHINE

A column type engraving machine of the two dimensional principle supports engraving head by a steering mechanism underneath the pantograph. The movement of the head is controlled by the horizontal pantograph. The regulating slide is fitted above a pin which meshes with a ball bearing above the head.

The ratio of the pantograph adjustment can be changed from 1:1 to 1:100 according to a table on the machine, achieving desired reductions by means of one template.

Total lengths of the steering arms for the engraving head are adjustable. Pantograph support swivels around precision bearing.

*Franz Kuhlmann KG*

Circle 124 on postcard for more data

## TOOLING COMPONENTS MOUNTED ON STAND

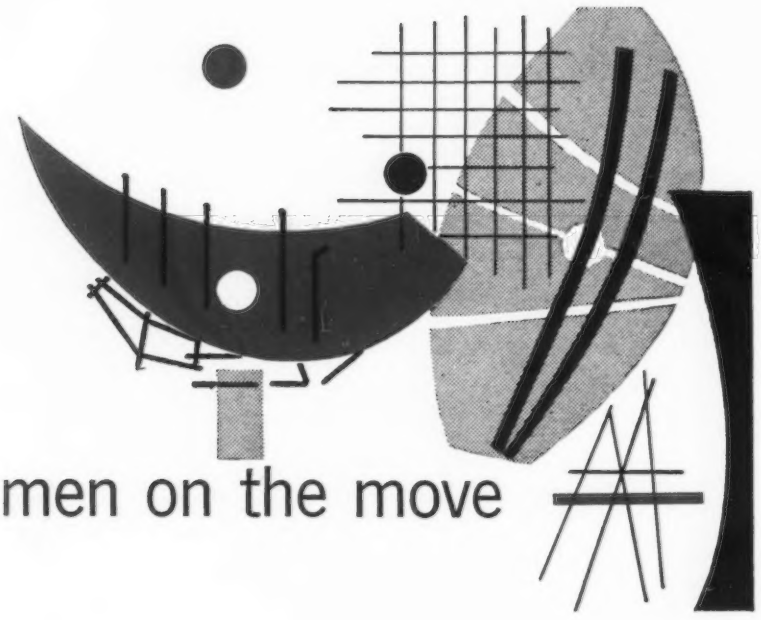
A new Circular Production Table Assembly provides mounting space for up to six tooling components for small parts machining in automatic production.

Table can be manually turned for fixture positioning. With a 27½-in. column, and a clamp for holding table and base, it permits a variety of fixturing and set-up to solve single or multiple drilling, tapping, facing, chamfering and similar machining operations on long or short runs.

Shown are the Dumore Circular Production Table Assembly and a typical set-up with three Dumore Series 28 Automatic "Drill-N-Tap" units nose mounted, with simple brackets.

*The Dumore Company*

Circle 130 on postcard for more data



# men on the move

GUSTAV O. HOGLUND, head of the welding section of the Aluminum Co. of America Process Development Laboratory, has been elected president of the American Welding Society.

WARREN C. HANSEN has been appointed manager of the new Washington office of Ellis and Watts Products, Inc., Cincinnati, O.

EDWARD J. FORISCH has been appointed to the staff of Wm. C. Whitehead, president of Aerol Associates.

THOMAS F. D'ANDRADE has been appointed national sales manager for the Components Div., Fairchild Controls Corp., Hicksville, N. Y.

FRED O. DRAPER has been appointed supervisor of production and supply for Republic Aviation Corp.'s Helicopter Div.

J. H. OVERHOLSER is president of the Hydrodyne Corp., newly-formed for the manufacture of fluid control products.

ROBERT T. SKINNER is executive vice president of Hydrodyne.

MARVIN B. RUFFIN has been named vice president and general manager of Chicago Aerial Industries, Inc., Melrose Park, Ill.

STANLEY E. HUFFMAN, JR., has been appointed to the new position of manager of sales for the press division of E. W. Bliss Co.

WALTER K. DEACON is new chief engineer, Torrance Plant, Aero Hydraulics Div., Vickers Inc.

EARL R. SKAGGS has been appointed executive vice president of Townsend Engineered Products, Inc., Santa Ana, Calif.

HARRY H. WETZEL has been named manager of The Garrett Corp.'s AiResearch Manufacturing Div., Los Angeles.

H. H. CLARKE, JR., has been elected president of Dyna-Therm Chemical Corp., formerly called Ideal Chemical Products Inc., Culver City, Calif.

GEORGE JOYCE was elected executive vice president of Dyna-Therm.

GUSTAV O. HOGLUND
Alcoa

WARREN C. HANSEN
Ellis & Watts

J. H. OVERHOLSER
Hydrodyne

GEN. JAMES M. GAVIN assumed duties as vice president of Arthur D. Little, Inc., Cambridge, Mass., on June 1. The former Chief of Research and Development for the Army was also elected a director of the firm.

C. GOULD WHEELER was named manager of material control for the team supervising the ballistic missile radar system subcontracted to General Electric.

W. RALPH WILCOX was named manager of manufacturing control.

MICHAEL R. DE LALLO was named manager of Missile Detection Systems Administration.

RICHARD W. COUCH was appointed project manager for the Air Force's Ballistic Missile Early Warning System (BMEWS) data processing project at Sylvania Electronic Systems, division of Sylvania Electric Products Inc.

A. E. THIESSEN, vice president, General Radio Co., Cambridge, Mass., was elected SAMA (Scientific Apparatus Makers Asso.) Industrial Instrument Section chairman.

SIDNEY STARK has been appointed operations manager for the Army's new Pershing missile at the guided missile and electronics center of the Martin Co. in Orlando, Fla.

DR. HENRY M. WATTS has been named chief engineer.

HUBERT BENNETT has been appointed assistant director, Applications Engineering Dept., and coordinator of field engineering for McCormick Selph Associates, Hollister, Calif.

FRANK L. SPENCER was appointed assistant manager of engineering program development for the Technical Products Div., Waste King Corp., Los Angeles.

GEORGES L. PANNIER has been appointed consulting engineer for the Metallizing Co. of Los Angeles, Inc.

GEORGE H. HAUSER has been appointed assistant to the president of Republic Aviation Corp.

H. LEE BRANDENBURG has been named manager of the Greenville, Mich., operation of Hupp Aviation Co.

DAVID MacMORRIS will represent Sundstrand Turbo in the firm's new eastern office in Washington, D. C.

M. MARK WATKINS has been appointed president of Conoflow Corp., Phila.

JOHN C. KOCH has been appointed executive vice president of Conoflow.

EDWIN A. RANEY has been appointed manager, Dynamics Div., Wyle Research Corp.

RICHARD L. ENGLE has been named manager of Allis-Chalmers Industries Group Pacific Region.

CHARLES W. BAKER, Los Angeles, has been promoted to assistant general sales manager for Chase Brass & Copper Co. He had served as western regional manager since 1952.

ROBERT A. WILSON has joined Exide Industrial Div., The Electric Storage Battery Co., Phila., in the new position of assistant to the missile products manager of the Missile Applications Dept.

CHESTER W. LARSEN was named general manager of The Greenleaf Manufacturing Co., St. Louis.

STANLEY C. PACE, assistant manager of the newly-formed Tapco Group, for Thompson Products Inc., was elected a vice president at the firm's meeting of shareholders.

**GEORGES L. PANNIER**
**Metallizing Co. of Los Angeles**

**EDWIN A. RANEY**
**Wyle Research**

**ROBERT A. WILSON**
**Exide**

### Label Embosser

Applications and tape prices of portable labeler ideal for identifying repair jobs are summarized in brochure.

*Dymo Corp.*

Circle 139 on postcard for more data

### Subminiature Pressure Pickups

Features of pressure pickups under physical abuse as in missile flight are given in bulletin kit.

*Consolidated Electrodynamics Corp.*

Circle 144 on postcard for more data

### Brazing Data

Illustrated data aimed at the service trades simplifies aspects of metal joinery. Titled "Brazing Manual," it aims at self-instruction or on-the-job training.

*All-State Welding Alloys Co.*

Circle 133 on postcard for more data

### Materials in Motion

Meeting materials handling problems for industry is subject of new catalogue.

*National Vulcanized Fibre Co.*

Circle 141 on postcard for more data

### High-Temperature Rivets

A new eight-page catalog illustrates uses of high temperature, high-strength drive-pin blind rivets. Illustrated, and including specifications and application notes, it serves as a guide in aircraft applications.

*Deutsch Fastener Corp.*

Circle 148 on postcard for more data

### Missile Facts

Eight page guided missile data sheet lists all missiles for the Air Force, Army and Navy by name and purpose up to February 10. It gives names and addresses of prime contractors and component sub-contractors.

*LaSalle Steel Co.*

Circle 137 on postcard for more data

### Measurement Glossary

A 20-pg. pocket size glossary, illustrated, explains terms frequently used in pressure and temperature instrumentation.

*Trans-Sonics Inc.*

Circle 138 on postcard for more data

### Sleeving and Tubing

Comprehensive catalogue T-58 of Biraco, Birflon, and Birflex sleeving and tubing includes price and stock sheets with cross reference chart.

*Birnbach Radio Co.*

Circle 150 on postcard for more data

### Variable Transformer

The 100-pg. Powerstat variable transformer Bulletin P258G serves as a reference manual-catalog. It covers product information, engineering data, outline drawings, connections, ratings, charts and illustrations on all standard 50/60 cycle Powerstats plus some special use types.

*The Superior Electric Co.*

Circle 152 on postcard for more data

### Chemical Milling

Illustrated 30-page color brochure on chemical milling and metal finishing describes advantages and engineering applications of process.

*Anadite Inc.*

Circle 142 on postcard for more data

### Beryllium Metal

A 24-page illustrated booklet, "Facts About Brush QMV Beryllium."

*The Brush Beryllium Co.*

Circle 134 on postcard for more data

### Rectification Plants

Rectification plants for producing oxygen and/or nitrogen in liquid or gaseous form are described in a new catalogue. Station Pumps with vaporizers and storage and converter tanks for liquid oxygen, hydrogen and argon are also illustrated and described. Technical data is included.

*Superior Air Products Co.*

Circle 143 on postcard for more data

### Titanium Welding Techniques

"Titanium Welding Techniques," comprehensive evaluation of successful welding methods, is available.

*Titanium Metals Corp. of America*

Circle 153 on postcard for more data

### Amplifiers

Cardboard - bound 1958 catalogue describes general uses, mechanical construction, and electrical data of I. F. amplifiers for radar and guided missile applications.

*Lel, Inc.*

Circle 132 on postcard for more data

### Relays

Operating data, dimensions, general uses of standard basic designs of relays are given in 35-page illustrated catalogue.

*Comar Electric Co.*

Circle 147 on postcard for more data

### Air Sampler

Line of air samplers described in brochure includes one testing hazardous matter exhausted during tests of rocket and missile propellants.

*The Staplex Co.*

Circle 149 on postcard for more data

### Temperature Conversions

A pocket-size low temperature conversion table gives conversions including degrees Celsius to degrees Fahrenheit and Kelvin from absolute zero to 0°C.

*Trans-Sonics Inc.*

Circle 138 on postcard for more data

### Wall Chart

A wall chart answers problems in cold cutting of metal. Chart is divided into four major sections listing problems with subsidiary segments providing solutions.

*Ernest F. Donley's Sons, Inc.*

Circle 135 on postcard for more data

### Cast Stainless Steels

Details on machining, welding and heat treating cast corrosion resistant and heat resistant high alloys are digested in a six-page folder; specific numerical data covers each of fourteen cast corrosion resistant alloys, and fourteen cast heat resistant alloys.

*Alloy Casting Institute*

Circle 151 on postcard for more data

### Steel Properties

A 40-page booklet describes investment-cast properties of stainless steel types 310, 316, 347, 410, 431 low-carbon, 431 high-carbon, and 440C, low alloy steels 4130, 4140, 6150, and Haynes 1000 steel.

*Haynes Stellite Co.*

Circle 146 on postcard for more data

### Lithium Hydride

Properties and uses of Lithium Hydride with bibliography are given in revised data sheet.

*Foote Mineral Co.*

Circle 140 on postcard for more data

### Janitrol

An 80-pg. book describes full activities, equipment, background of aircraft firm.

*Janitrol Aircraft Div. Surface Combustion Corp.*

Circle 145 on postcard for more data

### Self-Locking Clinch Nuts

Illustrated handbook, Design Manual 5803, reviews standard and miniature types of clinch nuts for the avionic, electronic and electrical equipment industries.

*Elastic Stop Nut Corp. of America*

Circle 136 on postcard for more data

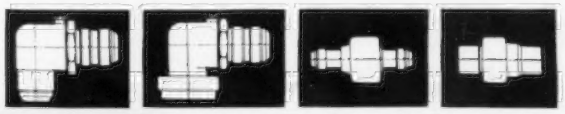

**DOWN-TO-EARTH FACTS...**

**about SEALOL swivel joints**

**10 inch-pounds swiveling torque at 3000 PSI**

Military Specification MIL-J-5513A allows 120 inch-pounds of torque on swivel joints like that shown. In both Type I and Type II Systems, the extremely low swiveling torque (10 inch-pounds at 3000 PSI) of these Sealol units makes more hydraulic power available for the service intended. All Sealol Aircraft Swivel Joints are designed to meet and exceed your most exacting specifications . . . for minimum torque and maximum leak-free life. Ask us to prove it!

**TYPICAL CUSTOM-DESIGNED SEALOL SWIVEL JOINTS**



**SEALOL**

**SEALOL CORP**
**426 Post Rd., Providence 5, R. I.**

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Name .....

Title .....

Company .....

Street .....

City ..... State .....

# industry notes

## FRENCH-DESIGNED STATOPLAN FOR PRIVATE FLYING

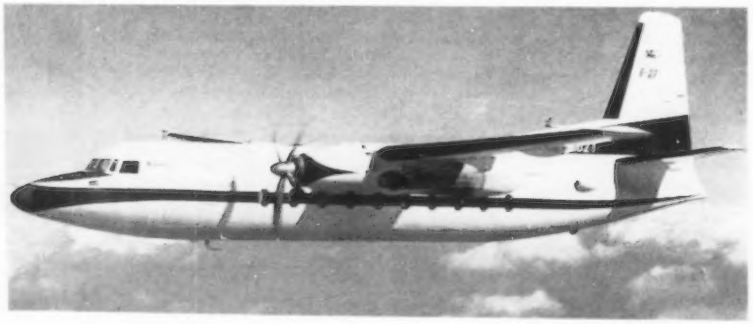
A relatively cheap approach to the STOL aircraft problem is the tandem wing aircraft designed by a French engineer, M. Gatard. Two different designs using his principle have appeared, and a third is under construction. For reasons of economy both the Statoplan types 01 and 02, as they are known, have been small aircraft. The first was intended purely for research, while type 02 has been designed with an eye to the do-it-yourself market which is very strong in France.

To make the principle work, slightly unconventional methods of control are used.

The front wing is hinged about its aerodynamic center. Longitudinal control is provided by linking this directly with the stick so that fore and aft movement varies the lift. The rear wing moves as a single unit, i.e., it has no control surfaces upon it. Slow speed flying is effected with both wings giving positive lift. To touch down during landing, the stick is pulled back to stall the front wing and allow sink; the rear wing is not stalled and still carries a fraction of the load and so the rate of sink is always slow.

The Statoplan employs a cambered rear wing with an area about 25 per cent of the main wing. Slotted flaps along

## MAIDEN FLIGHT FOR F-27



Fairchild's F-27, 40-passenger propjet airliner, on its maiden flight. Ninety-three F-27's have been ordered and the first delivery will be made to West Coast Airlines (serving the Pacific Northwest) late this month.

Powered by two Rolls-Royce Dart propjet engines, the F-27 is first twin-propjet transport in U. S.

the entire main wing trailing edge are connected to the stick so that lift control is provided by variation of the wing camber. The rear wing is interconnected with the flaps to provide pitching equilibrium throughout their range of movement. Full differential flap action is always available for lateral control.

Because camber, rather than angle of attack, controls the flight path, the fuselage datum remains nearly horizontal throughout the speed range. At maximum lift the fuselage datum of the 02 is at no more than 4° to the horizontal, therefore good forward visibility is always available, and body drag is minimized. For larger aircraft this would mean a short landing gear with a consequent reduction of drag and weight, while floors would be nearly level for loading purposes.

Air foil sections employed are of the NACA 230 series with the main wing employing a 12 per cent envelope and the rear wing a 10 per cent envelope. Clean construction has been used to enhance laminar flow and to this end the sections have been modified to have a smaller leading edge radius. Construction is mainly of wood with metal cowlings and undercarriage.

## LYCOMING TO PRODUCE HELICOPTER GAS TURBINE

The first military contract for major production of a helicopter gas turbine engine has been announced by Lycoming Div., Avco Manufacturing Corp.

Expected to total approximately $10 million, the Air Force-Army contract calls for delivery of Lycoming T53-L-1 engines starting January, 1959. A contract has already been received for $3 million of the amount. The engines are scheduled for use in two helicopters, the Army Bell HU-1 Iroquois, utility helicopter, and the Air Force H43B crash rescue helicopter.

The 825 eshp T53 engine has also been successfully flown as a twin engine installation in the Vertol Model 105, a modified H-21 "Flying Banana."

In addition, the engine is installed in three VTOL STOL vehicles currently undergoing initial flight testing for Army evaluation by Vertol, Ryan and Doak aircraft companies. A new turboprop version of the T53 has been selected by the Army to power the Grumman AO-1 Mohawk observation aircraft.

## ELECTRA CHOSEN FOR ANTI-SUB WARFARE

The Navy has chosen Lockheed's *Electra* turboprop aircraft for use in anti-submarine warfare.

Choice of the *Electra* came after an extensive evaluation study comparing several planes, according to Rear Admiral Robert E. Dixon, Chief of the Bureau of Aeronautics.

All the aircraft considered had been previously developed either for commercial or military use. Admiral Dixon stated that such "off the shelf" procurement will save time and money in ultimate delivery to naval operating forces. A commercial version of the Electra will enter service with the airlines this fall.

The Electra was found closest to Navy requirements for a land based ASW aircraft. A research and development contract with the Lockheed Corp. for a "mock up" model and further outfitting study will follow shortly.

Electra will be powered by four Allison T-56 turboprop engines, will carry a crew of ten, and will be equipped with latest instrumentation for the detection and destruction of

*continued on next page*


**HUNTER**
**INSTANT LIGHTING TORCHES**

***for military applications at sub-zero temperatures***

- developed in co-ordination with Engineer Research and Development Laboratories, Ft. Belvoir, Va.
- unpowered, open flame burners — lighted instantly with a match at temperatures down to −90°F.
- burn any type gasoline or JP-4 fuel.
- for a wide range of sub-zero, spot heat applications: small engine starting; start-aid for bulldozers, snow plows, earthmovers, special-purpose equipment; de-icing bogie wheels, tracks, heavy-duty control equipment, etc.
- capacities: 15,000 to 200,000 BTU/Hour at variable pressures.

*Other Hunter military equipment: space and personnel heaters; engine heaters; refrigeration units.*

GET THESE BROCHURES TODAY!

***for complete specifications and details***

MH-167 "Hunter Instant Lighting Torches"

MH-166 "Hunter Engine Heaters"

MH-162 "Hunter Space and Personnel Heaters"

**HUNTER** MANUFACTURING CO.
30537 AURORA RD.
SOLON, OHIO
HEATING AND REFRIGERATION SYSTEMS

Circle 46 on Inquiry Card, page 65

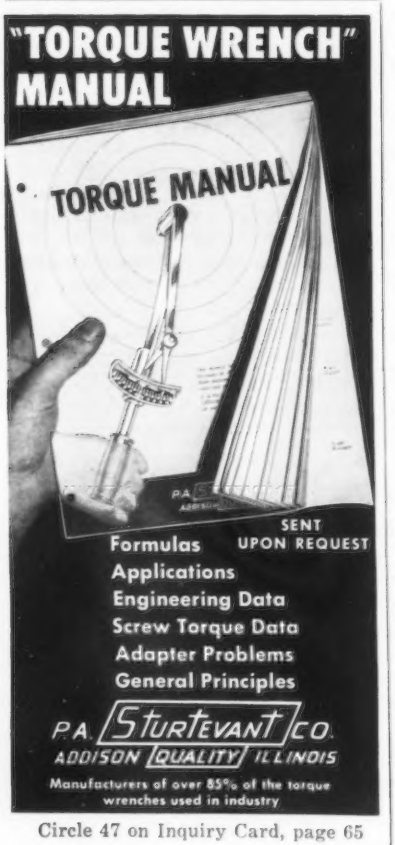
industry notes

enemy submarines. It will eventually replace the famous P2V Neptune series of Navy ASW aircraft which has had the longest lifespan of any military aircraft built by Lockheed, dating to 1944.

## THE THREE W's

Who buys what, and where, in the government?

The Small Business Administration answers the question in a new 106-page directory. Entitled the "U. S. Government Purchasing and Specifications Directory," it lists agencies, sources of specifications, and buying procedures.

Circle 47 on Inquiry Card, page 65

## COMMERCIAL JET ENGINE

The CJ-805, GE's contribution to the commercial jet engine boom, is moving into its second testing stage this month after successfully completing its initial 150-hour flight test.

After 25 days of flights in a leased Douglas XF4D Skyray, tests with the first, prototype, model of the CJ-805 were discontinued. They resume this month with a version incorporating several design refinements.

The first tests reached 10 hours per day utilization rate. No engine adjustments were necessary over the test period.

The CJ-805 is shown being installed in the Skyray at the GE Flight Test Center at Edwards Air Force Base.

Test pilots report completely satisfactory engine performance. Current plans are to exceed a 100 hr per month utilization rate with the XF4D by the end of the year.

The XF4D is the same aircraft which was used for the first flight of the firm's J79 engine in December 1955. This marked the first time an engine manufacturer flew an engine as a prime mover before turning it over to the airframe builder.

GE is also offering the jet engine with an aft-fan component which improves cruise fuel economy by about 10 per cent and increases take-off thrust about 35 per cent. The jetliner version is designated the CJ-805-21.

The new component has been found most valuable in the Mach .80 to Mach .90 speed range which may be used by commercial jetliners and military tankers for many years to come. Added to the rear of the basic gas generator of the straight jet, the component is a single stage, free fan. Turbine discharge air from the basic engine drives it as it compresses by-pass air ducted from the engine.

## AIR-TO-SURFACE BULLPUP FOUND ACCURATE

The Navy reports that its air-to-surface "Bullpup" missile is proving highly accurate in tests with a Pacific fleet.

Being produced at Martin's Orlando, Fla., plant, the missile is fired from specially-equipped planes to support ground troops.

Launched far from the target and out of range of ground fire, Bullpup has been found more effective than standard dive bombing. It is 11 ft long and weighs 600 lb.

## LARGE INDUCTANCE COIL USED FOR MISSILE STUDY

An inductance coil with 119 in. diam helps supply energy for Tunnel Hotshot II, special facility near Tullahoma in aerodynamics and aeronautics.

The coil, largest in the world, was designed and built at Westinghouse Electric Corp.'s transformer division, Sharon, Pa. Wound with 36 850-mcm cables in parallel, it supplies energy to an electric arc tunnel. After contacts in series with the coil are opened, air in the arc chamber is heated to 40,000 degrees F and pressure reaches 30,000 psi. Hot gas is released through the test section at 32,400 mph.

Maintained in the Gas Dynamics Facility of the Arnold Enginering Development Center, Hotshot II studies such problems as re-entry of a missile into the atmosphere.

## TWO ICBM SITES ANNOUNCED FOR SAC

The Department of Defense has announced plans to construct two ICBM sites for Strategic Air Command, one in the Offutt AFB, Omaha, area; the other in the Fairchild AFB, Washington, area.

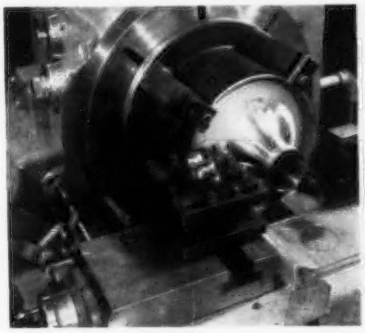
Construction cost for each site is estimated at $25-million. Work is scheduled to start in late summer or early fall of this year.

Approximately 750 personnel will be assigned to support and operation of each missile activity.

Technical design of the missile facilities will be under control of the Air Force Ballistic Missile Division, Inglewood, California. Other aspects of the design and all construction will be accomplished through the Corps of Engineers, Dept. of the Army, acting as the Air Force construction agency.

## MACHINING ROCKET PARTS

Rocket Propellant Chamber rear case assembly receives



tracer controlled contour machining at United Aero Products Co., Burlington, N. J. Work piece, an extremely tough heat-treated forging, demands contour accuracy of less than 0.005 in., plus satin smooth finish to eliminate stress risers. Company uses carbide tooling and airgage tracer control, machining at a speed of 350 sfpm and 0.0052 ipr feed.

## AIRCRAFT TEMPERATURE

The National Bureau of Standards has developed a remote control recorder for studying temperature distribution and its variation with time, over the "skin" of an aircraft.

The instrument can record readings of 96 thermocouples in six seconds. After a recorder switch is set for automatic operation, thermocouple terminals are connected to calibrated meters whose dials are photographed on 16 mm movie film.


**STAINLESS**
**FlexDucts & Bellows**

- which handle high temperature corrosives
- which withstand drastic pressure changes, vibration & sinuous alignment

. . . designed and fabricated by U. S. Flex

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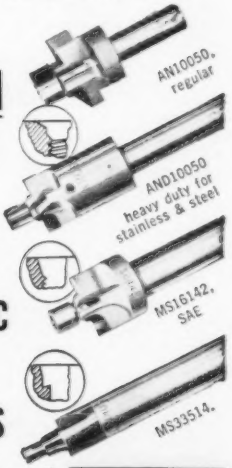
U. S. FLEXIBLE TUBING CO.
213 MAIN STREET BARTLETT, ILLINOIS

Circle 48 on Inquiry Card, page 65

**WHY BUY SPECIALS?**

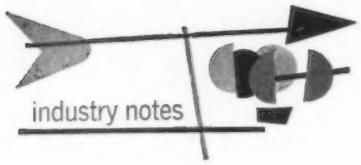
**Use standard cutters for popular hydraulic port contours**




One pass completes all operations necessary to produce the port contour. Job time cut as much as ⅔! All have carbide cutting edges for long life, smooth finishes. Available in all sizes. Write for prices.

SONNET
Tool and Mfg. Co.
576 North Prairie Avenue
Hawthorne
California

Circle 49 on Inquiry Card, page 65




# INDUSTRY STATISTICS

Source: Bureau of the Census and Civil Aeronautics Administration.

## VALUE OF NET SALES AND BACKLOG OF COMPLETE AIRCRAFT, AIRCRAFT ENGINES, AND PROPELLERS

All data are in Thousands of Dollars

### NET SALES

| Product and Type of Customer | Year 1957 | Year 1956 |
|---|---|---|
| Complete Aircraft and Parts | | |
| For U. S. Military Customers | $5,607,000 | $4,740,000 |
| For Other Customers | 1,165,000 | 814,000 |
| Total—Aircraft and Parts | $6,772,000 | $5,554,000 |
| Aircraft Engines and Parts | | |
| For U. S. Military Customers | $2,137,000 | $1,718,000 |
| For Other Customers | 390,000 | 317,000 |
| Total—Engines and Parts | $2,527,000 | $2,035,000 |
| Aircraft Propellers and Parts | | |
| For U. S. Military Customers | $ 140,000 | $ 101,000 |
| For Other Customers | 43,000 | 35,000 |
| Total—Propellers and Parts | $ 183,000 | $ 136,000 |
| Total—U. S. Military Customers | $7,884,000 | $6,559,000 |
| Total—Other Customers | 1,598,000 | 1,166,000 |
| Other Products and Services | $2,284,000 | $1,771,000 |
| Total—All Products | $11,766,000 | $9,496,000 |

### BACKLOG

| Product and Type of Customer | December 31 1957 | December 31 1956 |
|---|---|---|
| Complete Aircraft and Parts | | |
| For U. S. Military Customers | $ 6,426,000 | $ 8,837,000 |
| For Other Customers | 2,805,000 | 2,907,000 |
| Total—Aircraft and Parts | $ 9,231,000 | $11,744,000 |
| Aircraft Engines and Parts | | |
| For U. S. Military Customers | $ 2,379,000 | $ 3,316,000 |
| For Other Customers | 591,000 | 749,000 |
| Total—Engines and Parts | $ 2,970,000 | $ 4,065,000 |
| Aircraft Propellers and Parts | | |
| For U. S. Military Customers | $ 125,000 | $ 146,000 |
| For Other Customers | 33,000 | 45,000 |
| Total—Propellers and Parts | $ 158,000 | $ 191,000 |
| Total—U. S. Military Customers | $ 8,930,000 | $12,299,000 |
| Total—Other Customers | 3,429,000 | 3,701,000 |
| Other Products and Services | $ 2,161,000 | $ 2,350,000 |
| Total—All Products | $14,520,000 | $18,350,000 |

## NUMBER AND VALUE OF CIVIL AIRCRAFT SHIPMENTS

| Month | Units 1958 | Units 1957 | Value in Thousands 1958 | Value in Thousands 1957 |
|---|---|---|---|---|
| January | 579 | 584 | $ 62,311 | $ 48,431 |
| February | 510 | 523 | 65,046 | 49,278 |
| March | | 675 | | 46,636 |
| April | | 657 | | 57,980 |
| May | | 672 | | 84,136 |
| June | | 590 | | 69,497 |
| July | | 525 | | 70,649 |
| August | | 519 | | 62,990 |
| September | | 466 | | 54,911 |
| October | | 474 | | 45,687 |
| November | | 516 | | 47,213 |
| December | | 544 | | 44,856 |
| Total—Year | | 6,745 | | $682,264 |
| Total—2 Mos. | 1,089 | 1,107 | $127,357 | $ 97,709 |

## AIRFRAME WEIGHTS OF CIVIL AIRCRAFT SHIPMENTS

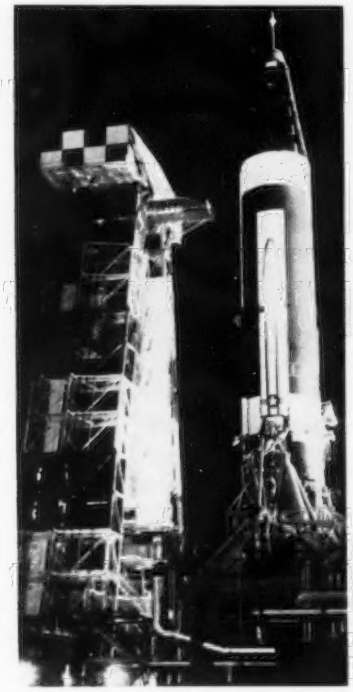
| Month | Thousands of lbs. 1958 | Thousands of lbs. 1957 | Avg./Aircraft 1958 | Avg./Aircraft 1957 |
|---|---|---|---|---|
| January | 1,909.9 | 1,574.9 | 3,299 | 2,697 |
| February | 1,891.4 | 1,554.0 | 3,709 | 2,971 |
| March | | 1,625.6 | | 2,408 |
| April | | 1,886.6 | | 2,871 |
| May | | 2,558.0 | | 3,806 |
| June | | 2,114.0 | | 3,583 |
| July | | 2,096.0 | | 3,992 |
| August | | 1,950.6 | | 3,758 |
| September | | 1,641.1 | | 3,522 |
| October | | 1,456.5 | | 3,073 |
| November | | 1,480.8 | | 2,870 |
| December | | 1,430.8 | | 2,630 |
| Total—Year | | 21,368.9 | | 3,168 |
| Total—2 Mos. | 3,801.3 | 3,128.9 | 3,491 | 2,826 |

## SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

| Month | Units 1958 | Units 1957 | Value 1958 | Value 1957 |
|---|---|---|---|---|
| January | 1,033 | 920 | $ 8,883,000 | $ 12,445,000 |
| February | 1,139 | 902 | 9,696,000 | 13,596,000 |
| March | | 1,010 | | 13,975,000 |
| April | | 950 | | 14,388,000 |
| May | | 1,020 | | 15,160,000 |
| June | | 933 | | 15,636,000 |
| July | | 801 | | 12,748,000 |
| August | | 776 | | 8,603,000 |
| September | | 728 | | 10,150,000 |
| October | | 921 | | 13,638,000 |
| November | | 878 | | 9,880,000 |
| December | | 1,020 | | 12,237,000 |
| Total—Year | | 10,859 | | $152,456,000 |
| Total—2 Mos. | 2,172 | 1,822 | $ 18,579,000 | $ 26,041,000 |

## TOTAL HP. OF AIRCRAFT PISTON ENGINE SHIPMENTS FOR CIVILIAN USE

| Month | Total Hp. (in Thousands) 1958 | Total Hp. (in Thousands) 1957 | Avg. Hp. per Engine 1958 | Avg. Hp. per Engine 1957 |
|---|---|---|---|---|
| January | 459.9 | 604.4 | 445 | 657 |
| February | 505.4 | 647.0 | 444 | 717 |
| March | | 679.2 | | 672 |
| April | | 668.2 | | 703 |
| May | | 715.8 | | 702 |
| June | | 730.4 | | 783 |
| July | | 590.4 | | 737 |
| August | | 425.6 | | 548 |
| September | | 482.8 | | 663 |
| October | | 628.3 | | 661 |
| November | | 473.0 | | 539 |
| December | | 586.2 | | 575 |
| Total—Year | | 7,231.3 | | 666 |
| Total—2 Mos. | 965.3 | 1,251.4 | 444 | 687 |



## STAINLESS ICBM

Atlas ICBM is practically a steel balloon.

Tanks comprising almost the entire length of the missile are of thin gage stainless steels.

Called "integral tanks" because they constitute about 90 per cent of the actual surface of the missile, they do not attain final shape and strength until internal tank pressurization.

Stainless steel was used to attain an ultra-lightweight structure with extreme tensile strength and high resistance to temperature and corrosion. Except for the warhead, the make-up of which is secret, the entire protective skin of the Atlas is of this iron, nickel and chromium alloy.

Like other ballistic missiles in the development stage, the Atlas is painted with broad vertical and horizontal stripes of special paint to allow photographic measurements of pitch and roll.

## SPACE CHALLENGE CITED FOR BALL BEARINGS

The director of M. I. T.'s Instrumentation Laboratory believes the instrument ball bearing industry will meet the challenge of satellites, rockets, and interplanetary ships by improving materials, equipment, and test methods.

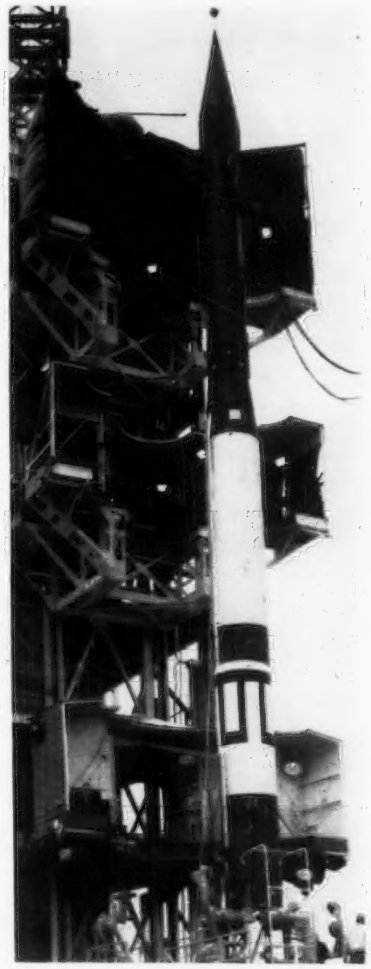
The director, Charles S. Draper, told the Instrument Ball Bearing Conference sponsored by the New Departure Division of General Motors that higher quality bearings are needed because bearing malfunctions "will very often cause over-all system failures." He cited the stresses from long flight times of space vehicles with their high speeds, temperatures and lubrication difficulties.

New materials offering promise, Draper said, include high speed steel and stainless steel alloys. These, with new heat treatments, he added, should "make it possible to reduce erratic plastic movements of gyro assemblies by approximately one order of magnitude from the movements now being realized in practice."

High precision instrument ball bearings are used in the inertial guidance (self contained) gyro stabilization systems of missiles such as Thor, Sibs and Achiever. Research is continuing on coefficients of friction, resistance to fatigue and oxidation.

Gyroscope precision is limited by forces in ball bearings causing "drift." Work is being done to reduce drift by using more small balls, the gothic arch ball bearing design, isoelastic gyro rotors, and separators of new thermo-plastic materials.

Because of the research, declares Draper, "the future of ball bearings in the age of space vehicles is bright."

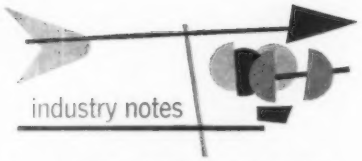


## TRIM VANGUARD SET FOR I.G.Y. TRY

Pictured above is the Navy's Vanguard missile before its May 26 launching in the first attempt planned specifically under the IGY program, to thrust a satellite into space.

Tagged SVL-1, the IGY attempt failed despite all three stages of the rocket firing successfully. A test firing on April 28 failed to put an instrumented 20-in. satellite into orbit because its third stage failed to ignite.

The rocket was sent off under the Navy IGY program calling for one launching a month. Different type satellite instruments will be used each time.



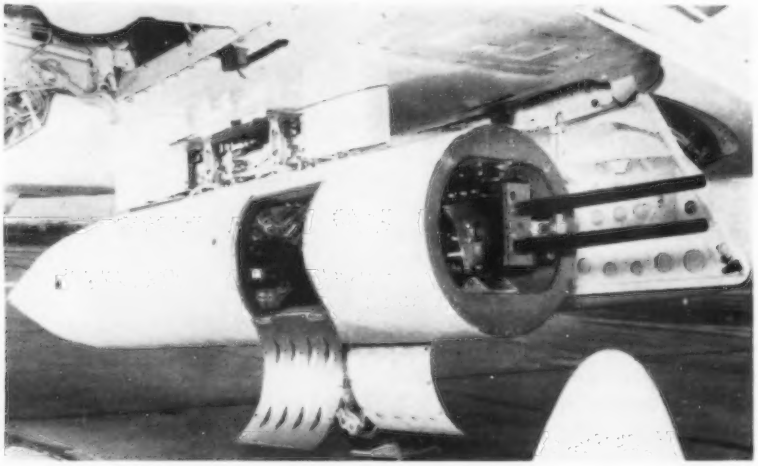

## GUN POD STRENGTHENS NAVY AIRCRAFT

An aircraft under-wing gun container carrying a new double-barreled 20 mm automatic cannon was shown at the recent Naval Air Weapons Meet by the Navy Bureau of Ordnance and The Aircraft Div. of Hughes Tool Co., Culver City, Calif.

The container, or pod, is attached to an aircraft by two connections, and can be jettisoned.

One pod equips a plane with the firepower of eight World War II 20 mm cannon.

Designated the Mark II, the cannon has a firing rate of 4000 high-explosive shells per minute, or 2000 per minute from each barrel. A single revolver cylinder feeds cartridges to both barrels. Any plane capable of carrying an 1100-lb load can be converted into a gun-firing tactical aircraft.



## FIGHTING FIRE BY HELICOPTER

The French D.T.I. has perfected special equipment small and light enough to be carried by the "Alouette" helicopter in fire-fighting operations. Operating on tribromofluorine, the equipment weighs about 814 lb. It can be set into operation in 30 sec.

## MACHINE TOOL BUILDERS IN WORLD MARKET

Machine tools are often called the Muscles of America. However, foreign competition and the recession are giving the domestic machine tool industry a real fight. The way the U. S. meets the challenge will have worldwide consequences.

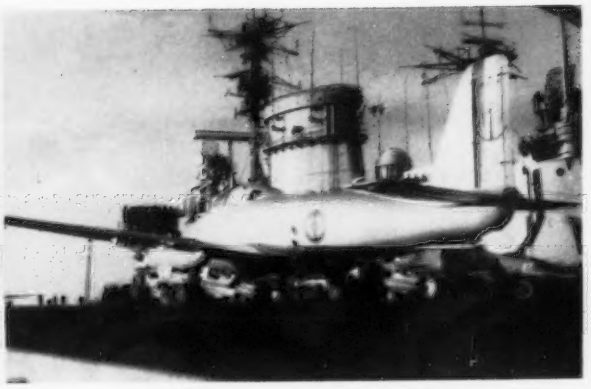
Top machine tool producers besides the U. S. are Russia, West Germany, and Great Britain. Russia claims annual output of 125,000. West Germany has snapped back from reparations to Russia in the last ten years to increase annual m-t production to over $700 million. British m-t production for 1957 was almost $1 billion. The U. S. output was $1,088,450,000.

What can the machine tool industry do? Here are some of the paths proposed at the National Machine Tool Builders Asso. conference:

1. Establish tariffs or quotas on machine tool imports.
2. Keep the present tariff system and meet competition through technological advances.
3. Some firms have made wholly-owned subsidiaries out of their distant competitors to operate in the European common market, where the dollar shortage has restricted importation of products made in the U. S. A.
4. Persuade foreign countries to loosen certain tariff and licensing restrictions.
5. Interpret the "Buy American" Act of 1953 so that heads of executive agencies would order from domestic producers.
6. Seek revised depreciation policies to provide five year amortization.

## JET TRAINERS FOR CARRIERS

Two naval versions of the Fouga 175 "Esquif" recently underwent qualification tests for use on aircraft carriers. These two-seater jet propelled trainers, going into initial production at Tolouse-Blagnac, performed successfully in 99 catapaultings and deck landings.



## ANTI-SUBMARINE AIRCRAFT

The Breguet 1050.03 and 04 "Alizé" successfully performed a series of tests by the French Naval Air Force. Officials said the plane complies with requirements for anti-submarine use with the new aircraft carriers of the French Navy. Tests were given at Hyères and Toulon.

# TERRA-SCOPE

A "Spacetronics" operation has been established at Allen B. Du Mont Laboratories, Clifton, N. J., for a unified effort in astronautic development.

Reaction Motors, Inc., first rocket engine firm in the U. S., has merged with Thiokol Chemical Corp., which becomes the surviving firm. Thiokol headquartered in Trenton, has developed and produced solid propellant engines since 1945. Reaction, Denville, N. J., established 1941, has concentrated mainly on advanced liquid propellant powerplants.

•

Solar Aircraft Company has announced a new $3,000,000 contract from the Air Force to build gas turbine powered airborne generator sets for the KC-135 jet tanker.

•

Data - Control Systems, Inc., Danbury, Conn., announced receipt of a contract from the Army for construction of a major data center for Army missile and satellite research programs.

Temco Aircraft Corp. has received an additional order for ailerons, tabs and wing flaps for the huge Lockheed C-130 Hercules military transport manufactured at Marietta, Ga.

•

Air Materiel Command has awarded Boeing Airplane Co. a contract totalling $202,866,300 for 130 KC-135A jet multi-purpose tanker-transport aircraft. This brings to 345 the total KC-135's now on order.

•

The Bureau of Ordnance has awarded Sperry Gyroscope Co., Div. of Sperry Rand Corp. three contracts, totaling $63 million, for producing major components for the TALOS and TERRIER guided missile systems.

•

Aerojet - General Corp. has received a $1,500,000 contract for solid propellant rocket development at its Sacramento, Calif., plant.

Philco Corp. has been awarded a $15-million contract for continued production of infrared guided Sidewinder missiles.

•

National Research Corp., Cambridge, Mass., and Laybold - Hochvakuum - Anlager, G.m.b.H., Cologne, Germany, have negotiated a five-year cross licensing agreement in high vacuum engineering.

•

Sylvania Electric Products, Inc., has been awarded an additional $23 million for expanded production of the electronic counter measures system for the Air Force B-58 "Hustler." The firm also was awarded an additional $4.5 million contract for expanded development of the PLATO anti-missile missile system.

•

The Singer Manufacturing Co. has formed a Military Products Div. to develop and produce electronic and electromechanical equipment for the defense industries and the Armed Forces, with special interest in the missile and space fields.

june 4-5
west coast symposium on magnesium applications in aircraft and missiles.
society of aircraft materials and process engineers; magnesium association.
institute of aeronautical science building, los angeles, calif.

◆

june 4-6
first national missile industry conference and dr. robert h. goddard memorial dinner.
american rocket society; national rocket club
mayflower hotel, washington, d. c.

◆

june 9-12
semi-annual meeting and astronautical exposition
american rocket society
hotel statler, los angeles, calif.

◆

june 9-13
fourth international automation congress and exposition
coliseum, n. y., n. y.

◆

june 15-19
semi-annual meeting
american society of mechanical engineers
hotel statler, detroit, mich.

◆

june 16-18
second national convention on military electronics
sheraton park hotel, washington, d. c.

◆

june 22-27
61st annual meeting
american society for testing materials
hotel statler, boston, mass.

◆

june 27
first water-based helicopter symposium
bureau of aeronautics; stevens institute of technology
stevens institute, hoboken, n. j.

◆

july 8-11
national summer meeting
institute of the aeronautical sciences
ambassador hotel, los angeles, calif.

◆

august 25-30
ninth annual congress
international astronautical federation
amsterdam, holland

## index to advertisers

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| | Page |
|---|---|
| American Ordnance Association | 3 |
| Apex Machine & Tool Co. | 55 |
| Arnav Aircraft Associates, Inc. | 59 |
| Burgmaster Corp. | Back Cover |
| Electric Steel Foundry Co. | 1 |
| Electro Tec Corp. | 56 |
| Gear Grinding Machine Co. | 47 |
| Hamilton Tool Co. | 70 |
| Hunter Mfg. Co. | 77 |
| Le Blond Machine Tool Co., R. K. | 15-16-17 |
| Magnaflux Corp. | Inside Front Cover |
| Menasco Mfg. Co. | 6 |
| Narda Ultrasonics Corp. | 5 |
| Nutt-Shel | 30-31 |
| Rolle Mfg. Co. | 61 |
| Sealol Corp. | 75 |
| Sharon Steel Corp. | 18-19 |
| Shell Oil Co. | 39 |
| Sonnet Tool & Mfg. Co. | 79 |
| Stackpole Carbon Co. | 69 |
| Sturtevant Co., P. A. | 78 |
| Temco Aircraft Corp. | Inside Back Cover |
| U. S. Flexible Tubing Co. | 79 |



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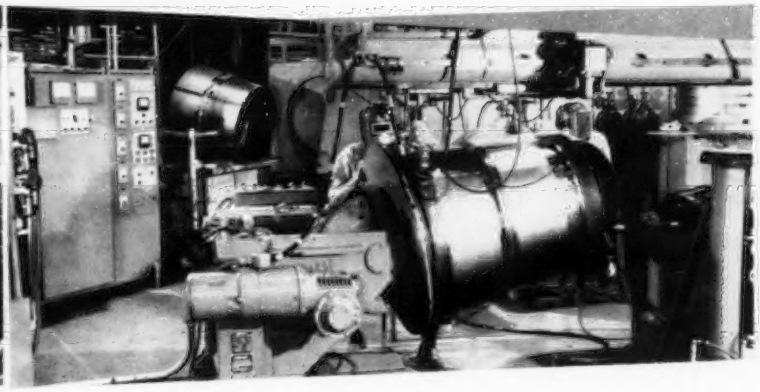
power plants and parts.

# Temco | AIRCRAFT DALLAS

## ..TITANIUM and TOMORROW



At Temco titanium is keeping its promises to the aircraft industry. No longer the intransigent metal, titanium in precision assemblies has become routine here. Through the development of Temco's Ti-Brite process, the tough titanium scale which once limited the material's usefulness is electrolytically removed without etching or disturbing the most precise dimensions.

And at Temco a successful process for chrome-plating titanium may be the major break-through in the feasibility study for extending its temperature resistance beyond the 800-1000°F range. Forming, spot welding, precision machining are everyday operations. Temco's proven capabilities in precision automatic fusion welding have proved especially effective in the assembly of titanium parts. A case in point: the front compressor casings of Pratt & Whitney's J-57 engine, produced at Temco.

Quality and reliability of assemblies produced at Temco are assured by the extensive facilities of the Quality Control Department and Metallurgical Laboratory. These include the newest non-destructive spectographic and large X-ray equipment.

Capabilities in advanced metallurgy . . in titanium, aluminum, austenitic steel, stainless steel . . are typical of Temco progress. And now research and development capabilities are challenging the rare earths . . berylium, columbium, tantalum, molybdenum . . for tomorrow's needs. As the aircraft industry grows, so do Temco's capabilities to design, tool and produce for it. **Whether your need is for a component, a subsystem or a complete system . . . an inspection of Temco will be informative and profitable.**

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Circle 29 on Inquiry Card, page 65

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# The new BURGMASTER®

## Bench Model Turret Drill

- Power indexes between stations
- Individual speeds on each spindle
- 2 complete speed ranges
- ¼" maximum capacity
- Protective overload slip clutches on spindle drive and indexing mechanisms

Here's the newest, most efficient drill press available for making small holes, faster! A Burgmaster *finishes* the job in the time normally required *to move work from spindle to spindle*—without machining! No lost motion, no operator fatigue...the powerful Burgmaster Bench Model drills up to ¼" diameters in steel; taps, counterbores, countersinks, reams, spot-faces!

**INSTANTLY INDEXES ITSELF** to each new station for a change of hole diameter or tooling. Duplicate operations can be performed with any spindle *without indexing.*

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*For greater output, for lower cost per hole get the new BURGMASTER Bench Model!*

**SPECIFICATIONS:** Maximum capacity, ¼" in steel; overall dimensions, height 31½"; width, 17"; depth 20"; motor, ¼ hp; chuck to base clearance, 10¼"; maximum spindle travel, 2⅞"; center of spindle to column clearance, 5⅜"; geared head permits each spindle to operate at a predetermined speed between 350-6200 rpm.

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Circle 30 on
Inquiry Card, page 65